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ELECTRONIC COMPUTER PROGRAM ABSTRACT

TITLE OF PROGRAM H7780 - Wave Runup and Wind Setup - Computational Model	**PROGRAM NO.** 723-X6-M007A
PREPARING AGENCY Southwestern Division, Corps of Engineers, 1200 Main Street, Dallas, TX 75202	

AUTHOR(S)	DATE PROGRAM COMPLETED	STATUS OF PROGRAM: PHASE	STATUS OF PROGRAM: STAGE
B. R. Bodine M. T. Hebler (WES)	Revised June 1978	MOD1	Operational

A. PURPOSE OF PROGRAM

The program provides a uniform method for calculating wave runup and wind set-up at the edge of lakes and reservoirs. Elevations of wave runup can be computed for embankment slopes that are either smooth, turfed, or riprapped. References: Refer to Appendix A.

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B. PROGRAM SPECIFICATIONS

SEE FOLLOWING PAGE.

LEVEL II

C. METHODS

The program is written in G635 time-share series, FORTRAN IV, and is part of a Conversationally Oriented Real-Time Program-Generating System (CORPS).

D. EQUIPMENT DETAILS

The basic program was developed on CDC 7600, Southwestern Division, Dallas, TX. The revised computer version in this abstract is now operational on the WES G635, Vicksburg, MS; HIS 66/80, Macon, GA; and Boeing CDC, Seattle, WA.

E. INPUT-OUTPUT

All inputs for program H7780 are either read from a permanent data file or are cued and read upon entry to the input subroutine H7780I. All specific input/output requirements for program H7780 are given in PART II: COMPUTER FUNCTIONAL DESCRIPTION of this abstract.

F. ADDITIONAL REMARKS

The basic program was developed by B. R. Bodine, primarily based on the information presented in ETL 1110-2-221, "Wave Runup and Wind Setup on Reservoir Embankments" by Bruce L. McCartney. The coding has been revised at WES in order to accommodate the CORPS time-share features.

B. PROGRAM SPECIFICATIONS:

Language: ANSI FORTRAN (FORTRAN IV)

Solution Requirements: The run command

RUN WESLIB/CORPS/H7780, R

and all necessary inputs.

Method of Analysis: Wave runup and wind setup are solved by direct solution of algebraic equations except for the transitional depth wave length which is solved via an interactive technique.

Core Requirements G635: 15 K words

External Storage: Type of storage - disk. Each user may have an existing input data file with a maximum of 12 K G635 ASC II words. If the file does not exist, a user named file is created. If user decides to save tabulated output for graphics and/or other use, each output file may have a maximum of 12 K G635 ASC II words. This file may already exist or be created by the user during a run of H7780.

Restrictions: Refer to pages 18-22

General Equations: Refer to equations 10-18 as presented on pages 14-17.

Range of Quantities: Unlimited for practical application.

Accuracy: Governed by accuracy of input data.

REF: ER 1110-1-10 - ENGINEERING AND DESIGN - Engineering Computer Program Library Standards and Documentation, Appendix B

PART I: ENGINEERING DESCRIPTION

1. PROGRAM NUMBER: 723-X6-M007A

2. TITLE: H7780 - Wave Runup and Wind Setup - Computational Model

3. REVISION LOG: Program coding revised June 78 to accommodate the CORPS time-share features.

4. PURPOSE OF PROGRAM: To provide a uniform method for calculating wave runup and wind setup at the edge of lakes and reservoirs. Elevations of wave runup can be computed for embankment slopes that are either smooth, turfed, or riprapped.

References: Refer to Appendix A.

5. STEP SOLUTION:

a. Introduction:

The computer program outlined in this abstract has been developed specifically for estimating wave runup and wind setup at the edge of lakes or reservoirs. This program may also be used to estimate the elevations of wave runup at the edge of semienclosed water bodies such as bays and estuaries. However, the method used in the present solution scheme for estimating wind setup is not generally appropriate for semienclosed water bodies. The principles involved and estimating procedures used in developing the program are presented together with the limitations of the computational system. Example problems involving the determination of wave runup and wind setup in more or less typical lakes or reservoirs are presented to demonstrate the utility of the program and procedures necessary for application.

This abstract is not intended to stand on its own but rather serve as a supplement to ETL 1110-2-221 (McCartney, 1976) references in Appendix A. Inasmuch as the referenced ETL is self-contained in respect to estimating characteristics of wind-generated waves for deepwater conditions, guidance for estimating waves for transitional water and shallow water conditions is referenced to the Shore Protection Manual (1977). In the determination of freeboard allowances for high dams, water depths are usually deep and thus it is usually necessary to estimate wave runup on waves generated in deep water or nearly deep water. However, in some instances, the design of some slope protection measures, such as highway and railroad embankments and flood levees, the water depths over the wave generating area may be small and require that the wave characteristics be based on transitional water or shallow water conditions. Consequently, the present computational scheme includes wave prediction for both deep, transitional, and shallow water.

The program has been formulated in such a manner that the preparation of basic data is minimized. In addition, provisions have been made to allow determinations of wave runup and wind setup for one or more sites with a single computer run.

b. Input: The inputs are read from existing user input data file or are entered at run time via the user's input terminal device. The inputs are described in PART II: COMPUTER FUNCTIONAL DESCRIPTION, Part B, INPUT DATA DESCRIPTION.

c. Mathematical Formulation:

1. Design Wind. In the present program two options are provided for describing the design wind. The first of these is simply the specification of the design wind for a particular location based on actual wind records representative of the area. For this option the overland wind speed, U_L , in miles per hour is a basic input to the program. The overland wind speed is converted to the wind speed over water internal to the program based on previously adopted criteria presented in ETL 1110-2-221. These criteria relate the ratio, R , wind speed over water and land areas to the effective fetch, F , for wave generation as follows.

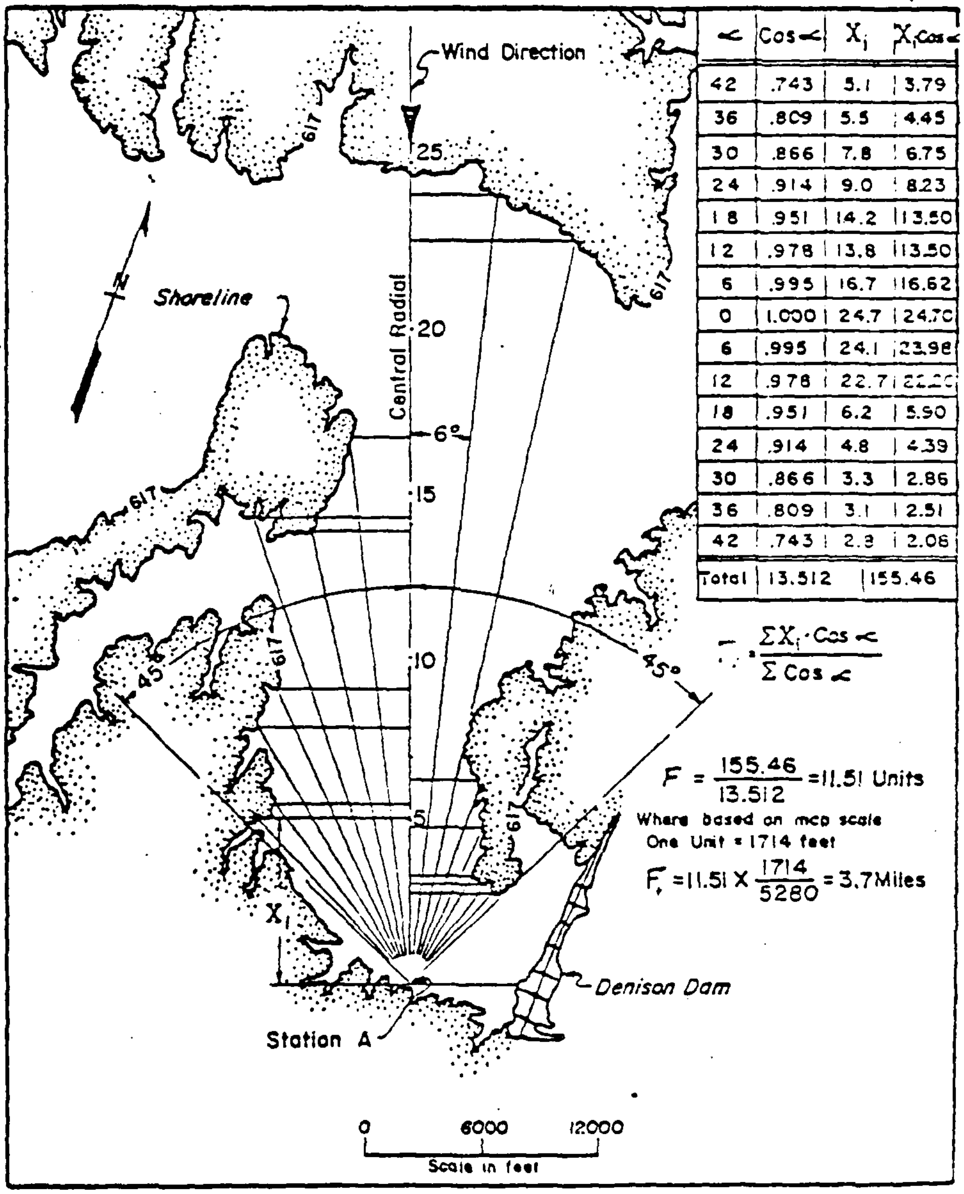
F (miles)	0.5	1	2	3	4	5 (or over)
$R_u = \frac{U_{overwater}}{U_{overland}}$	1.08	1.13	1.21	1.26	1.28	1.30

For convenience in programing the relationship, the ratio, R_u , is presumed to approach unity as the fetch approaches zero.

In the absence of sufficient wind observations for a particular site, the design wind may be determined from the averaged maximum regional wind data provided in ETL 1110-2-221. For this case, the maximum 1-minute and 60-minute averaged winds for a specific location are determined from the appropriate figures (Figures 2 through 9) in the ETL. These overland wind speeds are a basic input to the program. The adjustment to overwater wind speeds are determined internal to the program. Moreover, the design wind speed is calculated by a program subroutine. The techniques and procedures used for calculating the design wind speed is discussed in Appendix B.

2. Effective Fetch for Wave Generation. In the present computational scheme the effective fetch distance for wave generation is determined in accordance to the method developed by Saville et al. (1962) and outlined in ETL 1110-2-221. The procedure for determining the effective fetch distance, F, by this method is illustrated in Figure 1. It consists of superimposing radials on a suitable map which depicts the water body. The radials are constructed in a manner so that they emanate from the shoreline site where wave information is needed and extend across the water area until they intersect the shoreline. Even though some of the radial lengths may be zero, the central radial taken along the long axis of the water body will usually result in the longest effective wave fetch. The interval between any two adjacent radials is taken as 6 degrees (angle denoted by the symbol, α, on Figure 1) and the radials are limited by an angle of 45 degrees on either side of the wind direction. As a result of the bounds indicated, 15 radials are used in the determination of the effective fetch.

In the application of the effective fetch method in practice, question sometimes arises as to whether the radials have been constructed properly for maximum wave generation. On this basis, provisions have been made in the present computational scheme to input more than 15



α	Cos α	X_i	X_i Cos α
42	.743	5.1	3.79
36	.809	5.5	4.45
30	.866	7.8	6.75
24	.914	9.0	8.23
18	.951	14.2	13.50
12	.978	13.8	13.50
6	.995	16.7	16.62
0	1.000	24.7	24.70
6	.995	24.1	23.98
12	.978	22.7	22.20
18	.951	6.2	5.90
24	.914	4.8	4.39
30	.866	3.3	2.86
36	.809	3.1	2.51
42	.743	2.3	2.06
Total	13.512		155.46

(From Saville et al, 1962)

FIGURE 1 COMPUTATION OF EFFECTIVE WAVE FETCH radials, if desired. A special routine is included in the program to determine the effective fetch with the greatest length (referred to hereafter as the critical effective wave fetch) from a particular set of 15 sequential radials. It is to be noted, however, that a minimum of 15 radials are required as a basic input to the program.

3. <u>Effective Fetch for Wind Setup</u>. Fetch distance for use in estimating wind setup can usually be taken considerably longer than fetch distance used for wave generation. This is because wind setup effects may be transferred, to some extent, around substantial bends in the water body, thus warranting the assumption of a longer fetch. Guidance provided in ETL 1110-2-221 indicates that the wind setup fetch, F_u, can be estimated by using twice the effective wave fetch. For most problems encountered in practice, this is a sufficient estimate of the wind setup fetch. However, for some problems such an estimate may not always be realistic. Consider the example that all radial lengths are approximately equal for a given wave generation area. This would imply, as can be shown, that the effective wave fetch is approximately equal to 88 percent of the central radial length. Because of this particular condition, the wind setup fetch would exceed the central radial length by about 76 percent when using twice the effective wave fetch. As a consequence, this would infer that a portion of the wind setup fetch would be over water and another portion of the fetch would be over land. In the present computational scheme, this possibility is avoided by restricting the wind setup fetch to a distance less than or equal to the longest

radial length. Specifically, the wind setup fetch is equal to twice the effective wave fetch if this distance is less than the longest radial and equal to the longest radial if $2F$ is longer than the longest radial.

4. Wave Characteristics. The most fundamental description of waves induced by wind is their length L, height H, period T, and the wave depth d (see Figure 2). Inasmuch as wind waves are merely a more or less rhythmic change in the elevation of the water surface with essentially no net transport of the water, the wave form propagates in the direction of the wind by a velocity equal to L/T. This velocity is referred to as the phase velocity or wave celerity.

Surface waves induced by wind are classified in accordance to their lengths and the depths of water over which they travel, or specifically by ratio d/L. A wave is said to be a "deep water wave" if d/L is greater than 1/2, a "transitional wave" if d/L lies in a range between 1/25 and 1/2, and a "shallow water wave" if d/L is less than 1/25. The characteristics of deepwater waves are unaffected by the depth over which they propagate. On the other hand, waves in transitional and shallow water are affected by the depth in which they run, resulting primarily in the modification of the wave form. It is often said that transitional and shallow water waves feel bottom.

Observing waves under the influence of wind reveal that there is little regularity in wave form and the elevations of the rise and fall of the water surface. When attention is focused on say 1,000

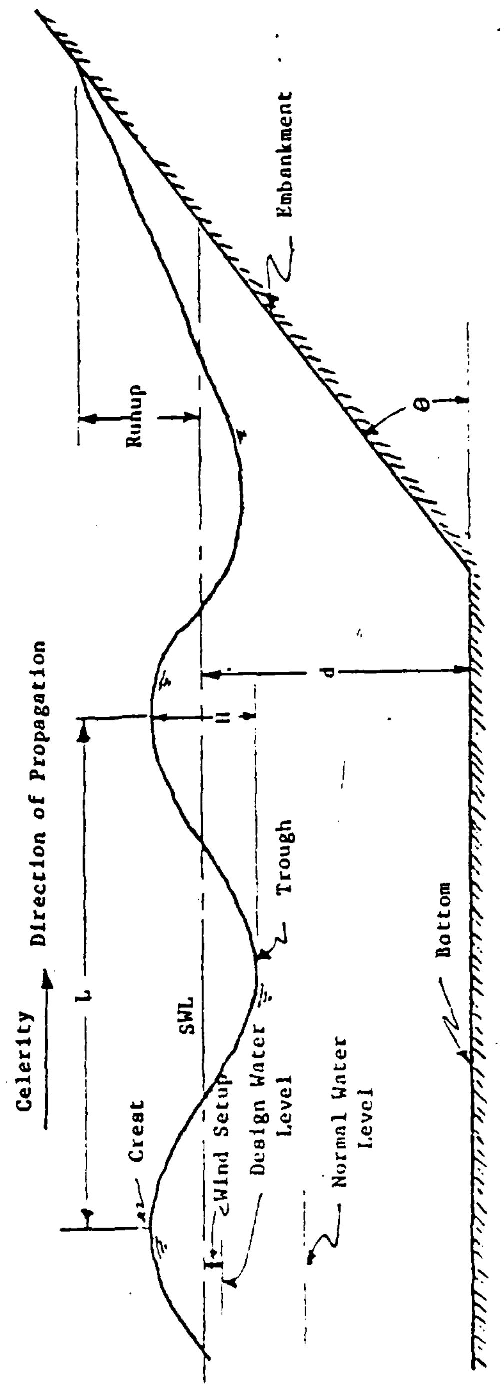


FIGURE 2 DEFINITION OF TERMS FOR WAVES

consecutive waves, referred to as a wave train, passing a fixed location it will be seen that there is considerable irregularity in wave form and wave height. Once the waves leave the generating area, the waves continue to propagate in the direction the wind was blowing, but they begin to transform into waves of more regular shape and more uniform height. In the solution of engineering problems for reservoirs and lakes, wave analysis is almost always concerned with waves under the influence of wind. Thus in dealing with such problems it is necessary from a theoretical point of view to represent the waves by an idealized description of the water surface. To facilitate this description a wave referred to as the "significant wave" has been postulated in which this wave has been almost universally adopted for the solution of wave problems. The significant wave height is defined as the average height of the one-third highest waves and written as H_s or $H_{1/3}$. The wave period associated with such a wave is called the significant wave period, T_s.

Occasionally, in the planning and design of shore structures it is advantageous to consider other waves in the wave spectrum for particular design analysis. This stems from the fact that in some instances it may be necessary or appropriate to provide a higher or lesser degree of protection than that afforded by the significant wave. Altering the degree of protection may be accomplished by selecting a specific wave height greater or smaller than the significant wave height. Other wave heights may be obtained and based on a knowledge of the significant wave height and utilizing the Rayleigh distribution function. The wave height distribution, accordingly, is given by

$$H_p = H_s\left(\frac{\ln 1/p}{2}\right)^{1/2} \tag{1}$$

where H_p is the wave height associated with a particular probability of exceedence, p, and ln signifies the natural logarithm. For example, a 1 percent wave height ($p = 0.01$) i.e., the elevation exceeded by 1 percent of the wave heights, according to equation (1) yields

$$H_{0.01} = H_s\left[\frac{\ln\ (1/0.01)}{2}\right]^{1/2} = 1.517\ H_s$$

Thus the 1 percent wave is about 1.5 times larger than the significant wave. The present solution scheme allows selection of a wave other than the significant wave for design purposes.

5. Wave Forecasting. A great deal of research effort has been devoted to the prediction of waves under the influence of the wind that generated them. As a result numerous wave prediction schemes have become available. Some of these schemes are complex while others are rather simple. A relatively simple wave prediction scheme which has been used rather extensively in practice is called the Sverdrup-Munk-Bretschneider (SMB) method. This method, as revised by Bretschneider in 1971, is discussed in the Shore Protection Manual (SPM, 1977) and is used for the method of wave forecasting in connection with the present solution scheme. The method involves estimating the wave characteristics (height and period) and the time period, called the duration, necessary to

generate the wave by semiempirical--semitheoretical formulae or by available wave forecasting curves (see SPM, 1977). The formulae, used in this development is presented in the following paragraphs for deep, transitional, and shallow water.

a. Deepwater waves. The wave forecasting equations for deep water are,

$$\frac{gH}{U^2} = 0.283 \tan h \left[0.0125 \left(\frac{gF}{U^2} \right)^{0.42} \right] \tag{2}$$

$$\frac{gT}{2\pi U} = 1.20 \tanh \left[0.077 \left(\frac{gF}{U^2} \right)^{0.25} \right] \tag{3}$$

and

$$\frac{gt}{U} = K \exp \left\{ \left[A \left(\ln \left(\frac{gF}{U^2} \right) \right)^2 - B \ln \left(\frac{gF}{U^2} \right) + C \right]^{1/2} + D \ln \left(\frac{gF}{U^2} \right) \right\} \tag{4}$$

where

$$\exp\{x\} = e^{\{x\}}$$
$$\ln = \log_e$$
$$K = 6.5882$$
$$A = 0.0161$$
$$B = 0.3692$$
$$C = 2.2024$$

and

$$D = 0.8798$$

The notations used are as follow: g is the acceleration of gravity; H is the wave height; U is the wind speed; F is the effective wave fetch distance; t is the duration; T is the wave period; and tanh is the hyperbolic tangent. Equations 2, 3, and 4 are nondimensional; and consequently, any system of units may be used. Units consisting of feet-seconds are used in the present computational scheme.

Subsequent to the determination of the wave period, the wave length in deep water L_o may be calculated by

$$L_o = \frac{gT^2}{2\pi} = 5.12\ T^2\ (\text{ft}) \tag{5}$$

This relation shows that the length of the wave in deep water is unaffected by the depth in which the wave travels (i.e., where $d/L_o > 0.5$).

b. Transitional and shallow water waves. Wave generation and wave characteristics are affected when waves are traveling in transitional and shallow water depths. For a given set of wind and fetch conditions, wave heights will be smaller and wave periods shorter in comparison to those in deep water.

The numerical technique presented here is based on successive approximations in which wave energy is added due to wind stress and subtracted due to bottom friction and percolation.

The equations applicable for transitional and shallow water conditions which incorporate bottom friction are as follows:

$$\frac{gH}{U^2} = 0.283 \tanh\left[0.530\left(\frac{gd}{U^2}\right)^{0.75}\right] \tanh\left\{\frac{0.0125\left(\frac{gF}{U^2}\right)^{0.42}}{\tanh\left[0.530\left(\frac{gd}{U^2}\right)^{0.75}\right]}\right\} \tag{6}$$

and

$$\frac{gT}{2\pi U} = 1.20 \tanh\left[0.833\left(\frac{gd}{U^2}\right)^{0.375}\right] \tanh\left\{\frac{0.077\left(\frac{gF}{U^2}\right)^{0.25}}{\tanh\left[0.833\left(\frac{gd}{U^2}\right)^{0.375}\right]}\right\} \qquad (7)$$

in which in deep water reduce to equations (2) and (3). Equations (6) and (7) are considered valid provided that wind blows over the water with sufficient duration to fully develop the waves.

In shallow water the wave length, L, is

$$L = T\sqrt{gd} \qquad (8)$$

in which the term $\sqrt{gd}$ is the wave celerity in shallow water.

For transitional depths the wave length, L, is given by

$$L = \frac{gt^2}{2\pi} \tanh\left(\frac{2\pi d}{L}\right) \qquad (9)$$

Evaluation of the wave length from equation (9) involves some difficulty since the unknown, L , appears on both sides of the equation. In the computer program developed, a special iterative and convergent scheme is used in the determination of L .

6. Wave Runup. The vertical height above the stillwater level (SWL) that a wave will run up the face of a structure (see Figure 2) depends on several factors. These factors are identified as structure shape and roughness, water depth at structure, bottom slope in front of the structure, and the characteristics of the waves impinging on the

structure. Because of the large number of variables involved and possible combinations of geometric shapes and wave conditions, an accurate description of wave runup phenomena is not available. However, a great deal of useful guidance has become available for estimating wave runup as a result of numerous laboratory studies conducted by using mechanical generated waves and some field studies. Seville (1955, 1956) Savage (1959), Saville et al. (1962), Battjes (1974), and Ahrens and McCartney (1975), among others, present the results of such studies.

A large number of laboratory experiments were conducted for runup on smooth plane slopes in 1956 (Saville, 1956). The results of these experiments were reproduced in graphic form and are presented in the recent Shore Protection Manual (1977). In 1965, Franzius, a German Engineer, transformed these graphical runup results into formulae which are convenient for computer applications. The relations obtained, as given by Battjes (1974), are as follows:

$$R = H \sin\theta\ (5.95 \tan\theta + 1.5) \left(\frac{0.123\ L}{H}\right)^{a} \tag{10}$$

where the exponent a is given by

$$a = \sqrt{\frac{H}{d_s}}\,(1.58 - 2.35 \tan\theta) + 0.092 \cot\theta - 0.26 \tag{11}$$

in which R is the wave runup, d_s is the depth of the water at the toe of the embankment, and θ is the angle between the horizontal and the embankment slope. Equation (10) is valid for

$$1/6 \leq \tan\theta \leq 1/2.25 \quad \text{and} \quad \frac{H}{d_s} \leq 0.475 \tag{12}$$

For a 1 on 1.5 slope the following equation is given

$$R = 2.3\ H \left[\frac{0.123L}{H}\right]^{(0.56\sqrt{H/d_s} - 0.18)} \tag{13}$$

For slopes flatter than a 1 on 6 slope, a formula given Battjes (1975) is used to estimate the wave runup. This equation is given by

$$R = 0.4\ T\sqrt{gH}\ \tan\theta \tag{14}$$

Franzius also found from experiments that the runup on smooth slopes could be modified to account for turfed slopes by the following approximate relation

$$R_T = (0.85 \text{ to } 0.90)\ R_s \tag{15}$$

in which R_T is the runup on a turfed slope and R_s is the runup on a smooth slope. In other words, the runup on a turfed slope is about 85 to 90 percent of the runup on a smooth slope. An approximate relation similar to equation (15) may also be given for impermeable stepped slopes in which the vertical and horizontal dimensions of the steps are relatively small compared to the wave height. Such a relation is given by

$$R_T = (0.7 \text{ to } 0.8)\ R_s \tag{16}$$

The factors 0.7 to 0.8 were based on data presented in SPM (1977) for stepped slopes and private communications with John Ahrens, Oceanographer, Coastal Structures Branch, Coastal Engineering Research Center.

For solution of other engineering problems, it is reasoned that runup for smooth slopes can be modified in the same manner for other slope surface conditions provided that the slope is uniform and the embankment surface is relatively smooth. Such a modification would not, however, be applicable to extremely rough slope surfaces.

In the case of riprapped embankment slopes, the relation given by McCartney (1976) provides a reasonable estimate of the runup. This relation is given by

$$R = \frac{H}{0.4 + (H/Lo)^{1/2} \cot \theta} \tag{17}$$

Equation (17) is considered valid for $2 < \cot \theta \leq 5$.

The equations given herein for estimating runup will normally be sufficient for resolving most problems encountered in reservoirs and lakes.

7. Wind Setup. The action of wind blowing over water surfaces of lakes and reservoirs is not only responsible for generating surface waves but causes the water surface to tilt from the windward side to the leeward side of the basin. The tilt is a result of the wind inducing a current in the upper layers of the water in the direction of the wind and thus causing the water to pile up at the leeward shore. A return current,

smaller in magnitude than the wind induced surface current, is established along the bottom in the opposite direction of the wind. At the upwind side of the basin the water level is depressed and at the downwind side the water level is raised as a result of the unequal surface and bottom current. The rise in water level at the downwind side of the water body is referred to as wind setup. The prediction of wind setup is complex due to the number of mechanisms and processes involved and the complications that arise in simulating the basin geometry. Although wind setup can be estimated with a reasonable degree of accuracy by sophisticated mathematical models presently available, there is usually little justification to do so for relatively small and deep lakes and reservoirs due to the substantial effort and expense in applying such schemes and the fact that wind setup is rather small in comparison to the wave setup.

A relation which in general gives a reasonably good estimate of the wind setup (see McCartney, 1976) is

$$S = \frac{U^2 F_u}{1440\ D} \tag{18}$$

in which S is the wind setup in feet; U is the wind speed in miles per hour; F_u is the wind setup fetch in miles and D is the average depth over the wind setup fetch in feet.

Equation (18) will generally provide conservative wind setup estimates at all locations in a relatively deepwater body except at those locations where the basin geometry converges to the shore site where interest is centered. For sites located in a highly convergent zone it may be justified to increase the wind setup as much as 50 percent to account for an additional pileup of water.

d. Output: The output consists of three parts; basic input, computational results, and user option output. The basic input and computational results are printed for each problem. The user option output (Wind Data and Deepwater Wave Characteristics and Wave Heights and Wave Runup for Waves Other Than the Significant Wave) is or is not printed according to user specification in the basic input. The tabulated output (user option output), if desired, may be stored in a user existing or run-time created output data file.

6. ACCURACY: Governed by accuracy of input data.

7. REMARKS:

a. General. Inasmuch as the computational model described herein will usually provide a reasonable estimate of wave runup and wind setup for most problems encountered in practice, there are some practical problems in which the model cannot be expected to yield meaningful results. Because the model is not applicable to all problems, care must be exercised in determining the practical limits in which the model can be applied. Determination of whether the model is applicable or not applicable to a specific problem area requires a careful review of the physical characteristics of the water body and embankment coupled with engineering judgment.

The model is limited to the determination of wave runup on uniform smooth, relatively smooth, and riprap slopes with waves approaching from a direction normal (90 degrees) to the slope. It is also applicable to stepped slopes in which the vertical and horizontal dimensions of the steps are small in comparison to the wave height. The model is not applicable to other nonuniform slope configurations, vertical walls, and for such slope covers as permeable rubble mound. Although the model does not apply for the cases mentioned, wave runup estimates can usually be made by the methods and procedures presented in SPM (1977).

The height and period of waves calculated in the model are determined from empirical wave forecast formulae in which it is assumed that wave propagation over the fetch occurs with a uniform depth. However, for real water bodies, depths can vary considerably over the wave fetch. In many cases when waves propagate over the fetch, the wave in one portion of the fetch may be a deepwater wave while at another a shallow water wave. However, a reasonable estimate of the height and period of waves can be obtained by using the average depth over the fetch provided that the wave does not break as it travels over the fetch. Theoretically, a wave height, H, cannot exceed 0.78d, where d is the local water depth. Waves breaking offshore from a structure result in a lower wave height at the structure. Thus, the reduced wave height should be used in determining the wave runup at the structure. No provisions are made in the present model to account for breaking waves and, therefore, it is necessary to account for this effect separately.

There are some instances when waves break along the path of wave propagation at a considerable distance from the site where interest is centered. For example, a roadway may transverse the water body at about right angles to the wind direction at about mdiway along the wave fetch. Under severe flooding conditions, the roadway may cause the waves to break as they pass over the top of the road. For such cases, an estimate of the design wave reaching the project site may be obtained by first obtaining the breaking wave height, H_b, over the roadway (i.e., $H_b = 0.78\ d_b$), and then determining the fetch required to generate the height of the breaking wave. The fetch necessary to generate the breaking wave may be determined from the appropriate wave forecasting curves presented in the SPM (1977). This fetch added to the fetch between the roadway and the project site can then be used to estimate the wave height and wave period at the project site.

The following problem will illustrate the determinations required to estimate the wave characteristics at a project site for the case when a roadway traversing a water body alters the effective wave fetch.

EXAMPLE PROBLEM

GIVEN: A roadway crosses a reservoir midway between the upwind side of the reservoir and the project site in which $F_1 = F_2 = 20{,}000$ feet. The fetch F_1 is the distance between the roadway and the upwind side of the reservoir, and F_2 is the downwind fetch. The wind speed, U, is 60 mph, $d_1 = d_2 = 35$ feet and the still water level is 5 feet above the roadway. At the project site, the embankment consists of a rip-rapped 1 on 3 slope.

<u>FIND</u>: Determine the height and period of the significant wave runup and total rise in water level at the project site.

<u>SOLUTION</u>:

$$H_b = 0.78 d_b = 0.78(5) = 3.9 \text{ feet}$$

From Figure 3-27, Volume I, SPM (1977), it is seen that the fetch required to generate the 3.9 foot wave is about 12,000 feet; therefore,

$$F = 20{,}000 + 12{,}000 = 32{,}000 \text{ feet}$$

For the modified fetch length, Figure 3-27 reveals that $H_s = 5.5$ feet and $T = 4.7$ seconds.

The deepwater wave length according to equation (5) is

$$Lo = 5.12\ T^2 = 5.12\ (4.7)^2 \simeq 113 \text{ feet}$$

and the significant wave runup (equation 17) is

$$R = \frac{Hs}{0.4\left(Hs/Lo\right)^{1/2} \cot\theta} = \frac{5.5}{0.4 + \left(5.5/113\right)^{1/2}\ (3)} = 5.18 \text{ feet}$$

The wind setup according to equation (18), assuming $D = d$, is

$$S = \frac{U^2\ F_u}{1400\ D} = \frac{(60)^2(2)(32{,}000)}{1400\ (35)\ 5280} = 0.89 \text{ feet}$$

The total rise in water level at the project site is

$$S + R = 0.89 + 5.18 \simeq 6.1 \text{ feet}$$

Finally, it should be noted that the model does not account for wave modification as a result of refraction, diffraction, and reflection. Reference is made to the Shore Protection Manual (1977) for treating such wave phenomena.

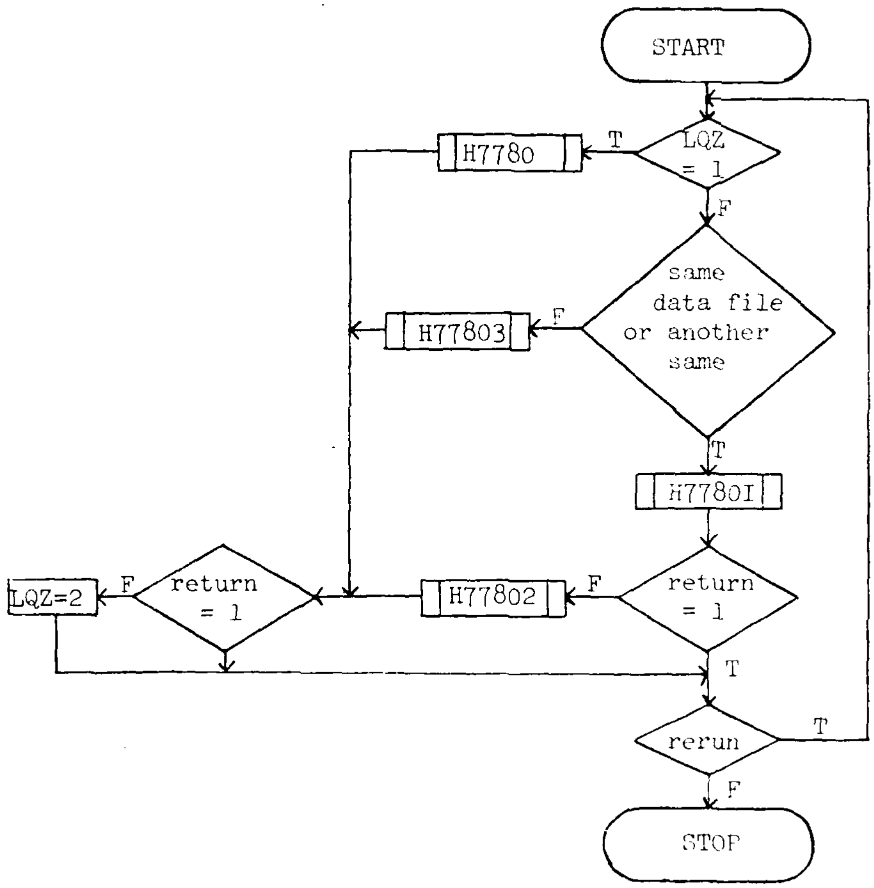
b. Acknowledgements. Many useful comments and suggestions either received or by personal communications have been extremely helpful to the author in development of the computer program and preparation of this report. In particular, a great deal of credit must go to R. A. Jackowski, Coastal Engineering Research Center (CERC) for his useful review comments and suggestions. Others who have made contributions are R. L. Hula, of the Southwestern Division Office; M. A. Fly, of the Tulsa District; B. L. McCartney, of the Office of Chief of Engineers; D. L. Harris, of CERC; and J. P. Ahrens, of CERC.

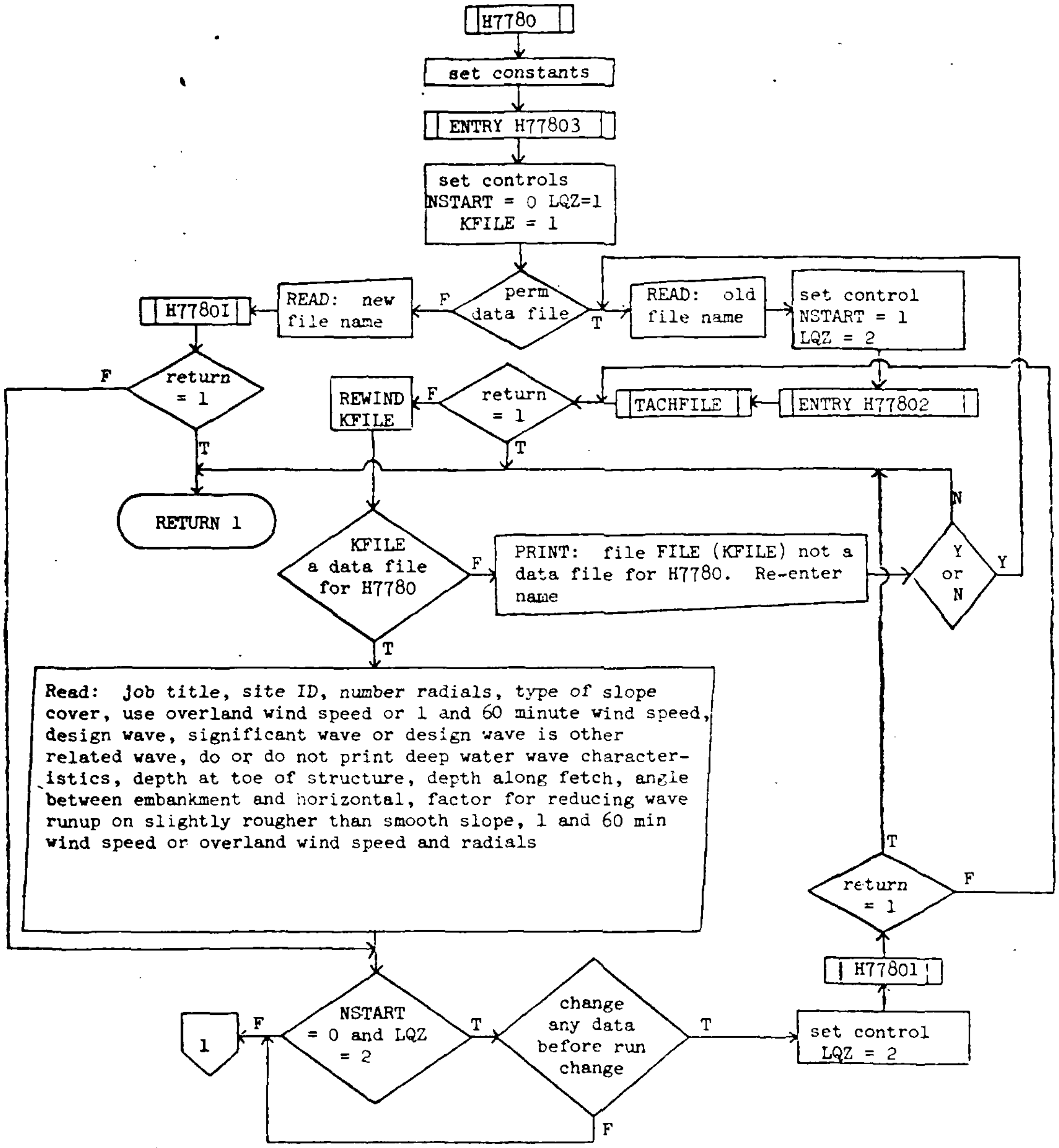
Finally, considerable credit must go to Mrs. K. J. Davis for editing and typing the report.

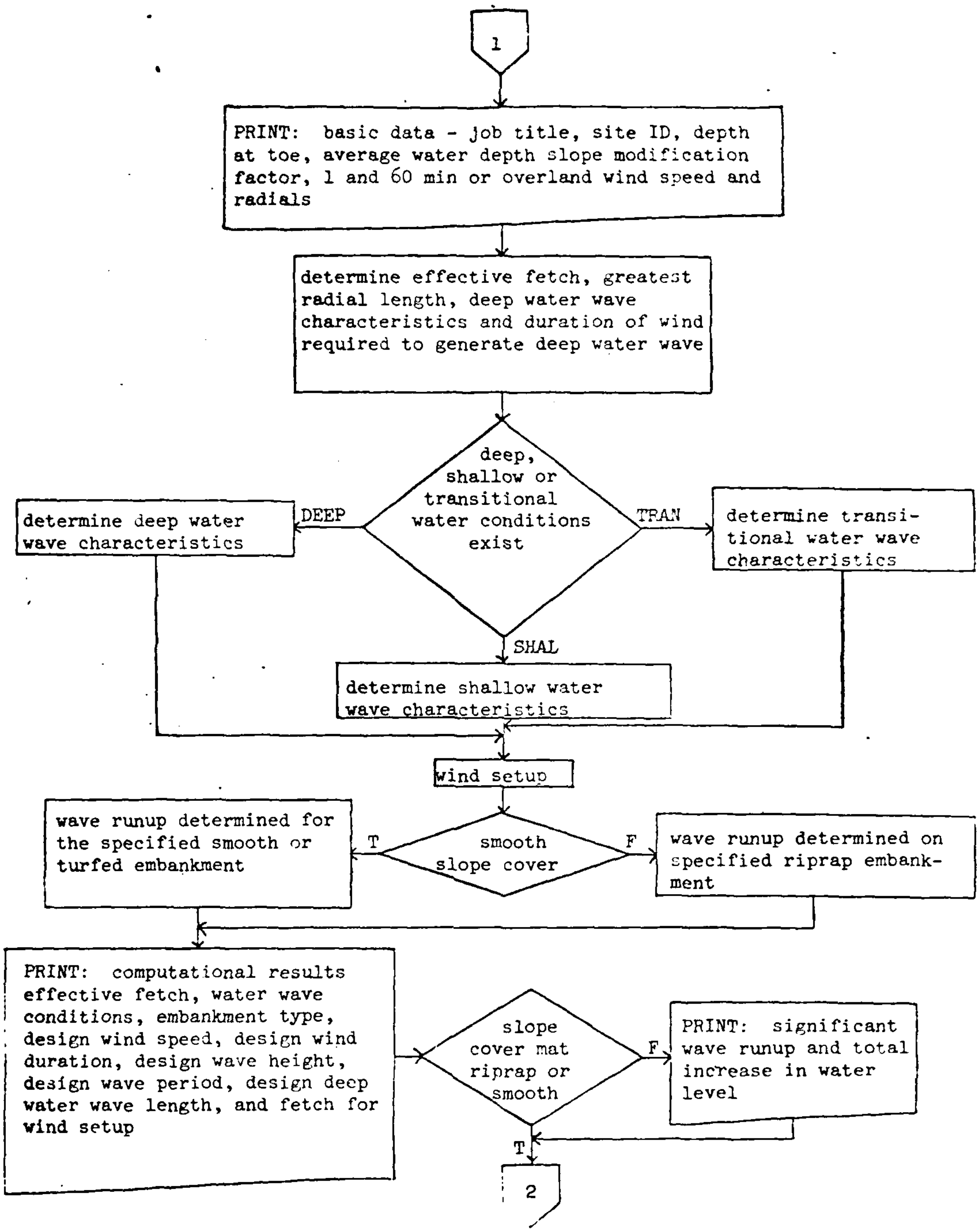
PART II: COMPUTER FUNCTIONAL DESCRIPTION

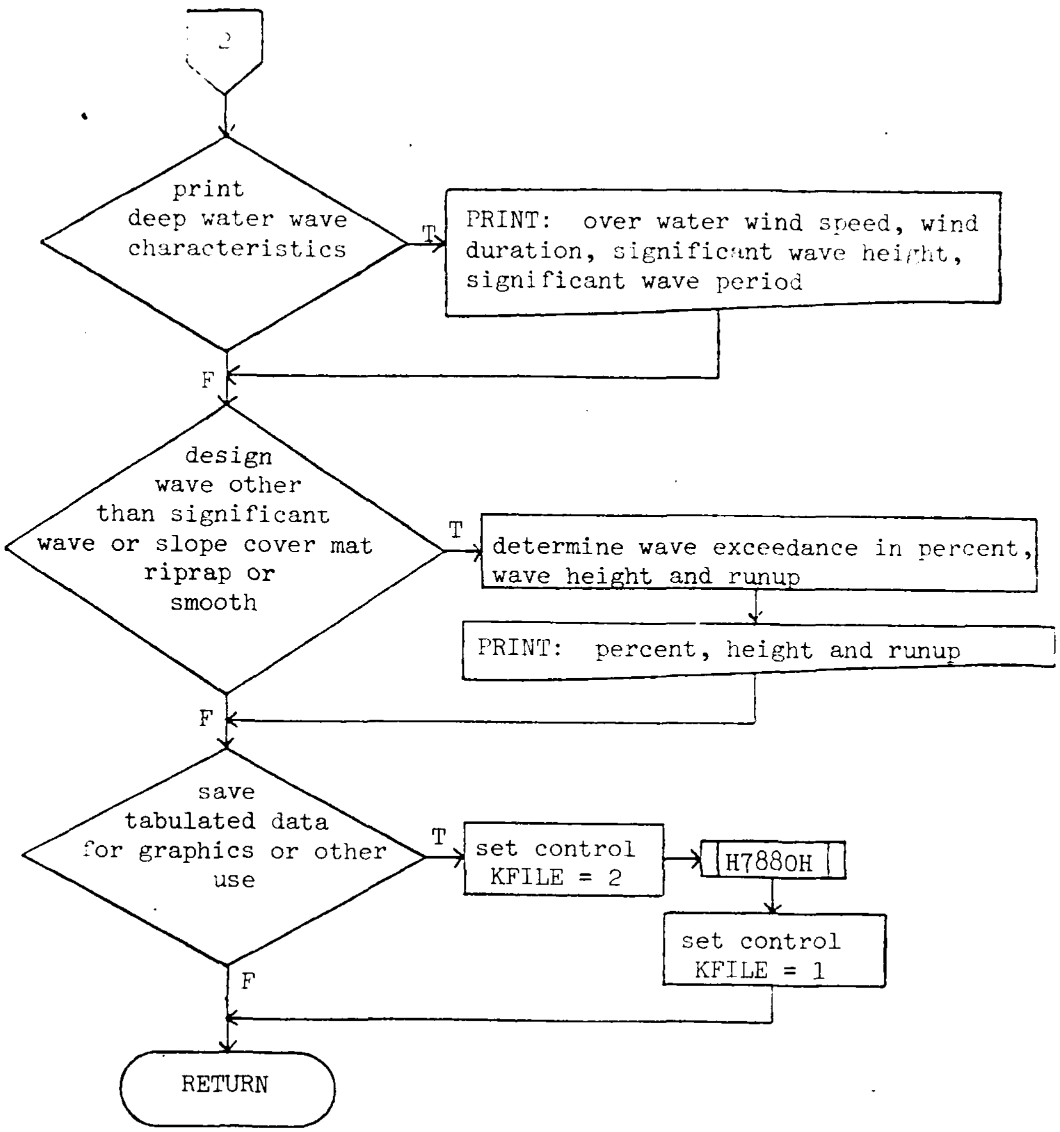
1. REVISION LOG: Program coding revised June 78 to accommodate the CORPS time-share features.

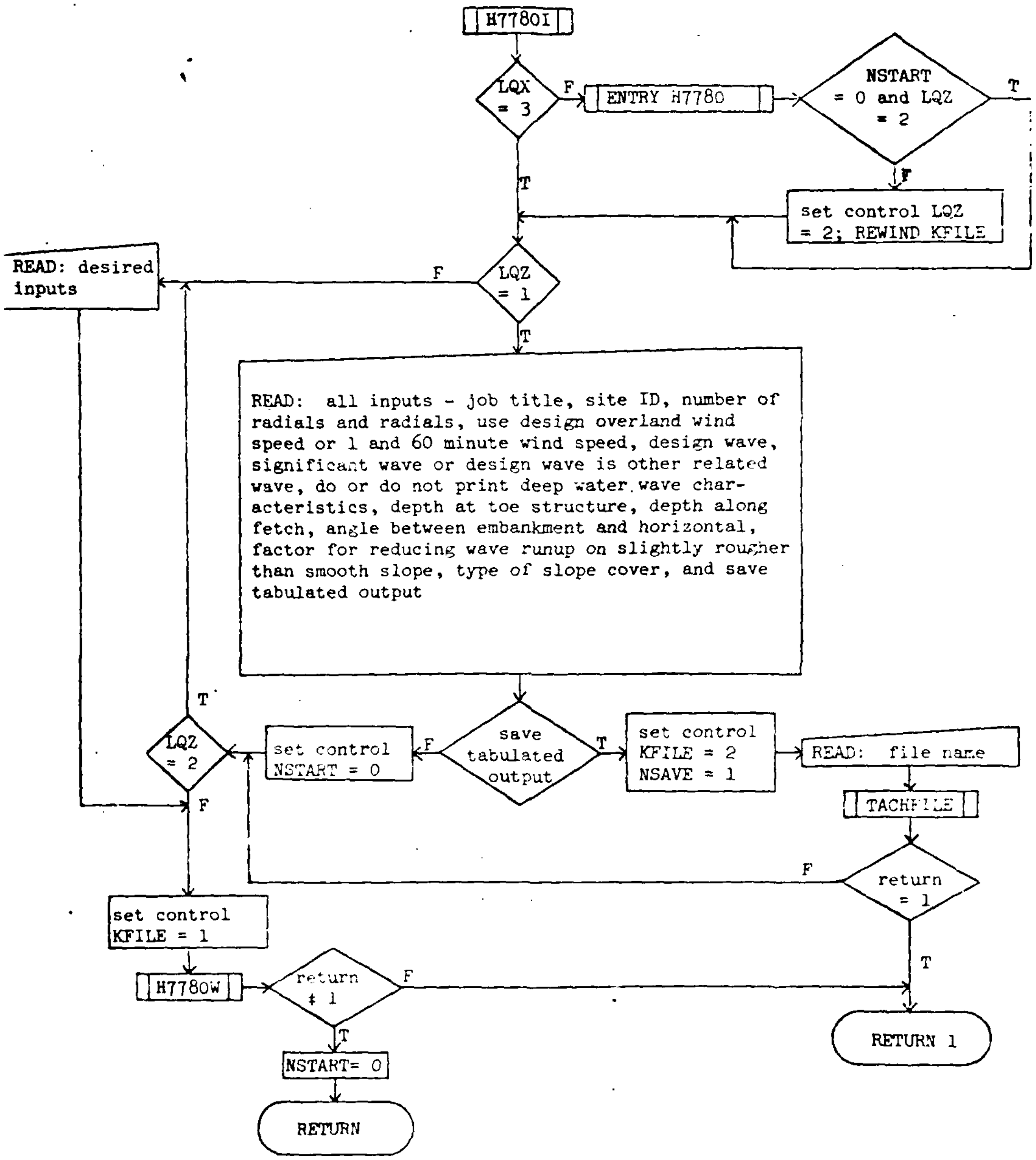
2. FUNCTIONAL FLOW CHART:

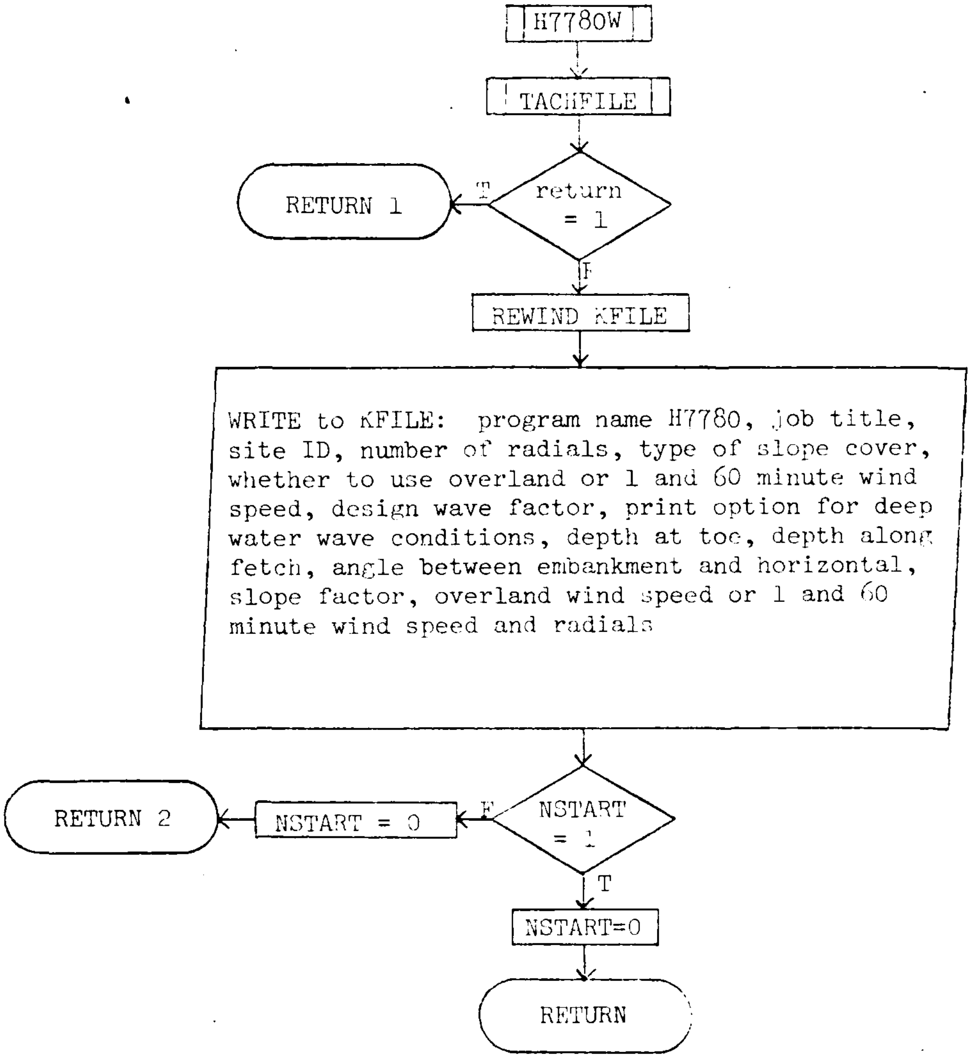


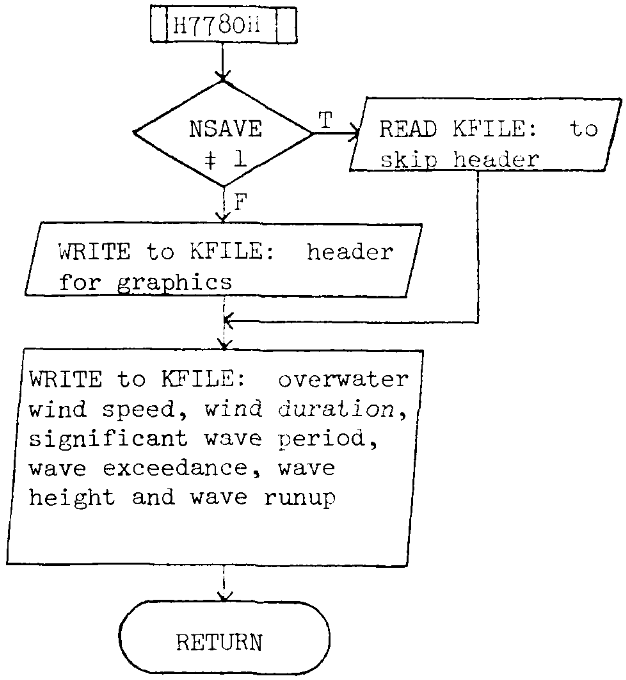

H7780
set constants
ENTRY H77803
set controls
NSTART = 0 LQZ=1
KFILE = 1
perm
data file
F
T
READ: new
file name
READ: old
file name
set control
NSTART = 1
LQZ = 2
H77801
return
= 1
F
T
REWIND
KFILE
F
return
= 1
T
TACHFILE
ENTRY H77802
RETURN 1
KFILE
a data file
for H7780
F
PRINT: file FILE (KFILE) not a
data file for H7780. Re-enter
name
N
Y
or
N
Y
T
Read: Job title, site ID, number radials, type of slope
cover, use overland wind speed or 1 and 60 minute wind speed,
design wave, significant wave or design wave is other
related wave, do or do not print deep water wave character-
istics, depth at toe of structure, depth along fetch, angle
between embankment and horizontal, factor for reducing wave
runup on slightly rougher than smooth slope, 1 and 60 min
wind speed or overland wind speed and radials
T
return
= 1
F
H77801
1
F
NSTART
= 0 and LQZ
= 2
T
change
any data
before run
change
T
set control
LQZ = 2
F


1
PRINT: basic data - job title, site ID, depth at toe, average water depth slope modification factor, 1 and 60 min or overland wind speed and radials
determine effective fetch, greatest radial length, deep water wave characteristics and duration of wind required to generate deep water wave
deep, shallow or transitional water conditions exist
DEEP
determine deep water wave characteristics
TRAN
determine transitional water wave characteristics
SHAL
determine shallow water wave characteristics
wind setup
smooth slope cover
T
wave runup determined for the specified smooth or turfed embankment
F
wave runup determined on specified riprap embankment
PRINT: computational results effective fetch, water wave conditions, embankment type, design wind speed, design wind duration, design wave height, design wave period, design deep water wave length, and fetch for wind setup
slope cover mat riprap or smooth
F
PRINT: significant wave runup and total increase in water level
T
2


2
print
deep water wave
characteristics
T
PRINT: over water wind speed, wind
duration, significant wave height,
significant wave period
F
design
wave other
than significant
wave or slope cover mat
riprap or
smooth
T
determine wave exceedance in percent,
wave height and runup
PRINT: percent, height and runup
F
save
tabulated data
for graphics or other
use
T
set control
KFILE = 2
H7880H
set control
KFILE = 1
F
RETURN


H7780I
LQX = 3
F
ENTRY H7780
NSTART = 0 and LQZ = 2
T
F
set control LQZ = 2; REWIND KFILE
T
READ: desired inputs
F
LQZ = 1
T
READ: all inputs - job title, site ID, number of radials and radials, use design overland wind speed or 1 and 60 minute wind speed, design wave, significant wave or design wave is other related wave, do or do not print deep water wave characteristics, depth at toe structure, depth along fetch, angle between embankment and horizontal, factor for reducing wave runup on slightly rougher than smooth slope, type of slope cover, and save tabulated output
T
LQZ = 2
F
set control NSTART = 0
F
save tabulated output
T
set control KFILE = 2 NSAVE = 1
READ: file name
TACHFILE
F
return = 1
T
set control KFILE = 1
H7780W
return ≠ 1
F
T
NSTART= 0
RETURN
RETURN 1


H7780W
TACHFILE
return = 1
T
RETURN 1
F
REWIND KFILE
WRITE to KFILE: program name H7780, job title, site ID, number of radials, type of slope cover, whether to use overland or 1 and 60 minute wind speed, design wave factor, print option for deep water wave conditions, depth at toe, depth along fetch, angle between embankment and horizontal, slope factor, overland wind speed or 1 and 60 minute wind speed and radials
NSTART = 1
F
NSTART = 0
RETURN 2
T
NSTART=0
RETURN


H7780H
NSAVE
≠ 1
T
READ KFILE: to skip header
F
WRITE to KFILE: header for graphics
WRITE to KFILE: overwater wind speed, wind duration, significant wave period, wave exceedance, wave height and wave runup
RETURN

3. EQUIPMENT AND OPERATING SYSTEM: The basic program was developed on CDC 7600, Southwestern Division, Dallas, TX. The revised computer version in this abstract was developed on a G635 time-share system in which input/output equipment consisted of a Model 33 remote teletype. It is now available on the WES G635, Vicksburg, MS; HIS 66/80, Macon, GA; and Boeing CDC, Seattle, WA.

4. *INPUT REQUIREMENTS: The required inputs are:*

   a. Read, in the computational subroutine H7780, *from* a user input data file.

   b. Entered, in subroutine H7780I, via the user's time-share terminal device in free field format. The inputs are passed to the computational subroutine H7780 via the COMMON statement.

5. SECONDARY STORAGE INPUT FORMAT: The formats for the user input data file, whether it already exists or is created during a run of H7780, are:

   a. READ:

```
10260 FORMAT (4X,A8)

10350 FORMAT (4X,15A4/4X,15A4/4X,5I3/4X,4F7.2,4X,2F7.2,7(/4X,
8F7.2))
```

Refer to line numbers 10250 and 10330-10340 of the source listing, page 61.

   b. WRITE:

```
16180 FORMAT (I3,"H7780",2(/I3,1X,15A4)/I3,1X,5I3/I3,1X,4F7.2/I3,
1X,2F7.2,7(/I3,1X,8F7.2))
```

Refer to line numbers 16150-16170 of the source listing, page 67.

6. INPUT DATA DESCRIPTION: The following names are used for the input variables in program H7780.

COTTH	- cotangent, angle between horizontal and embankment slope. Example - slope of 1 on 2, COTTH = 2.0.
D	- average water depth along wind fetch, ft
D1	- water depth at tow of structure, ft
FACT	- factor for adjusting slope roughness for relatively smooth slopes. FACT = 1.0 for smooth slopes; = 0.85 to 0.90 for turfed slopes
FILEK(1)	- 8 character variable for name of user input data file
FILEK(2)	- 8 character variable for name of user output data file for graphics and/or other use
IDES	- factor for design wave; 0, design wave is significant wave; 1, design wave is some other wave in a representative spectrum
IMM	- number of radials in evaluation of critical effective fetch; 15 minimum
X(I)	- length of radials for I = 1,...,IMM; miles
ITAB	- print option for deepwater wave characteristics of various wind speeds. ITAB = 1, print table of values; = 0, no print
ITYPE	- type of embankment slope cover. ITYPE = -1, riprap; = 0, smooth; = 1, other types
IWIND	- factor for design wind. IWIND = 0, input overland wind speed; = 1, input 1 and 60 minute wind speeds as provided in ETL 1110-2-221
UL	- overland wind speed, mph
U2	- maximum 1 minute wind speed, mph
U61	- maximum 60 minute wind speed, mph

SITE - 15 dimension, 4 character variable for site identification

TITLE - 15 dimension, 4 character variable for job title

7. OUTPUT DATA DESCRIPTION: The following names are used for the output variables in program H7780.

DL - design deepwater wave length, ft

FE - critical effective wave fetch, miles

FS - fetch for wind setup, miles

H - significant wave height (deepwater characteristics), ft

HD - design wave height, ft

HP - wave height for waves other than significant wave, ft

PPEP - wave exceedance. Exceedance refers to the percent of wave in a wave spectrum that exceeds a given value, percent

RP - wave runup for wave other than significant wave, ft

RS - significant wave runup, ft above SWL

RSS - total increase in water level, ft above SWL

S - wind setup, ft

T - significant wave period (deepwater characteristics), sec

TD - design wave period, sec

TDUR - wind duration (deepwater characteristics), min

TDURD - design wind duration, min

UD - design wind speed, mph

UF - over water wind speed (deepwater characteristics), mph

8. PROGRAM ERROR MESSAGES:

Messages from subroutine TACHFILE. TACHFILE is a file handling routine for CORPS H files.

a. If file name INDATA is entered as an existing, but does not exist, then

NO SUCH FILE INDATA   RE-ENTER NAME, Y OR N

is printed. If answer is Y, then the new file name is read and the file is attached. A reply of N returns control to the main program.

b. If INDATA does exist, but cannot be attached, then

FILE PROB. CALL M T HEBLER AT 88-542-2403 AND GIVE THIS
NUMBER ISTAT THANKS

where ISTAT is a 12 digit octal number. Control is returned to the main program.

c. If INDATA is busy, then

FILE INDATA   BUSY. ANOTHER FILE, Y OR N

is printed. If answer is Y, then the new file name is read and the file is attached. If N, control is returned to the main program.

d. If IN:DATA, which has the illegal character : in its file name occurs, then

ILLEGAL CHAR IN FILE NAME IN:DATA   RE-ENTER Y OR N is printed. If answer is Y, a new file name is read and the file attached. If N, control is returned to the main program.

e. If file INDATA is an existing attached file, but is not an input file for H7780, then

```
FILE INDATA    IS NOT AN INPUT FILE FOR H7780. RE-ENTER
Y OR N
```

is printed. If answer is Y, then the new file is attached and tested. If N, control is returned to the main program.

f. If file INDATA is an existing attached file, but is not an output file for H7780, then

```
FILE INDATA    IS NOT AN OUTPUT FILE FOR H7780. RE-ENTER
Y OR N
```

is printed. If answer is Y, the new file is attached and tested. If N, control is returned to the main program.

9. <u>VARIABLE DEFINITIONS</u>:

a. Main Program:

HFILE	- five character name of program; passed to WESLIB count routine HACCT
LQZ -	- equal 1, call subroutine H7780I and execute all input cues and reads; = 2, call WESLIB routine RERUN and enter only desired inputs
LQX	- equal 1, print instructions for RERUN; = 3, no print
ZZZZZ	- 2 character; = RE, rerun; = ST, stop

b. Subroutine H7780:

ADIFF - absolute value of the difference between the trial transitional depth wave length and the value of equation (9), page 13, ft

AI - wave exceedance in percent

ALEN - trial transitional depth wave length, ft

ALN - working storage; equal to the expression $A \ln\left(\frac{gF}{U^2}\right)^2$ of equation (4) page 11.

ALPHA(I) - angle between a specific radial line and the central radial, for I = 1,...,15, radians

AU - addition counter; adds 1 to over water wind speed for for each print, until maximum number of prints reached for wind data and deepwater wave characteristics

AU360 - natural log of wind speed for duration of 360 minutes, mph

AU60 - natural log of maximum 60 minute wind speed, mph

AO - working storage; equal to the expression $\exp(\ln U_{60} - A \ln 60)$ of equation (B-4), page B-3, Appendix B

A1 - absolute value of the reciprocal of the difference ratio between the natural logs of 60 and 360 minute wind speeds to the natural logs of 60 and 360

A60 - natural log of 60

A360 - natural log of 360

BLEN - value of equation (9) page 13 at trial transitional depth wave length, ft

BLN - working storage; equal to the expression $B \ln\left(\frac{gF}{U^2}\right)$ of equation (4) page 11

C - equal to 22/15; changes mph to fps

COTTH - cotangent; angle between embankment slope and horizontal. Example, slope of 1 on 2; COTTH = 2

D - average water depth along wind fetch, ft

DIFF - difference between trial transitional depth wave length and the value of equation (9) page 13 at trial transitional wave length, ft

DL - design deepwater wave length, ft

DLN - working storage; equal to the expression $D \ln\left(\frac{gF}{U^2}\right)$ of equation (4) page 11.

DS - depth at toe of structure plus wind setup, ft

D1 - depth of toe of structure, ft

F - effective fetch, miles

FACT - factor for adjusting slope roughness for relatively smooth slopes. FACT = 1, smooth slope; = .85 to .9, turfed slopes

FE - effective fetch (critical), miles

FES - effective fetch (critical), ft

FI(I) - fetch increments used in determining the factor for converting overland wind speed to overwater wind speed for I = 1,...,7

I	FI	I	FI	I	FI
1	0	2	.5	3	1
4	2	5	3	6	4
7	5				

FILEK(1) - 8 character name of input data file

FILEK(2) - 8 character name of output file for graphics and/or other use

FILET - 5 character name of CORPS H-file used to build input data file or output file for graphics and/or other use

FS - fetch for wind setup, miles

GD(I) - constants for equation (4) page 11 for I = 1,...,5

I	GD	I	GD	I	GD
1	6.5882	2	0.0161	3	0.3692
4	2.2024	5	0.8798		

GDU - working storage; equal to the expression $\frac{gd}{U^2}$ of equations (6) and (7) pages 12 and 13

GFU - working storage; equal to the expression $\frac{gF}{U^2}$ of equations (2), (3), and (4) page 11 and equations (6) and (7) pages 12 and 13

GH - working storage; equal to the expression tanh $\left(.0125\left(\frac{gF}{U^2}\right)^{.42}\right)$ of equation (2) page 11 and equation (6) page 12.

GRAV - acceleration of gravity, 32.2 ft/sec^2

GT - working storage; equal to the expression tanh $\left(.077\left(\frac{gF}{U^2}\right)^{.25}\right)$ of equation (3) page 11 and equation (7) page 13

GTA - working storage; equal to the expression $\frac{gt^2}{2\pi}$ of equation (9) page 13

GTB - working storage; equal to the expression $2\pi d$ of equation (9) page 13

G1 - working storage; equal to the expression tanh $\left(.53\left(\frac{gd}{U2}\right)^{.75}\right)$ of equation (6) page 12

G2 - working storage; equal to the expression tanh $\left(.833\left(\frac{gd}{U^2}\right)^{.375}\right)$ of equation (7) page 13

G3 - working storage; equal to the right hand-side of equation (6) page 12

G4 - working storage; equal to the right hand-side of equation (7) page 13

H(I) - significant wave height for wind data and deepwater wave characteristics, I = 1,...,IX; ft

HD - design wave height, ft

HFILE - 5 character name of program's CORPS H-file name (H7780)

HP(I) - wave heights for waves other than the significant wave, for I = 1,...,20;ft

IDES - factor for design wave; IDES = 0, design wave is significant wave; = 1, design wave is some other related wave

IFIN - switch; = 0, read angles between specific radial lines and central radial line from 42° down to 0°, = 1, read back up from 6° to 42°

II - counter in determination of effective fetch; = 1 if 15 radial lengths input; if > 15 radial lengths entered, increased one each time effective fetch scheme is entered until = number of radial lengths input - 15 + 1

IJK - counter in determination of effective fetch; = 15 if 15 radial length input; increased one each time effective fetch scheme is entered until = number of radial lengths input

IK - number of first radial length corresponding to critical effective fetch to be printed

IL - number of last radial length corresponding to critical effective fetch to be printed; = IK + 14

IMM - number of radial lengths input

INC - counter used in determination of deepwater wave characteristics; increased by 1 until a fetch increment used in determining the factor for converting overland wind speed to overwater wind speed is found ≥ to the critical effective fetch

ITAB - option for printing tabulation of deepwater wave characteristics; ITAB = 0, no print; = 1, print

ITYPE	- type of embankment cover; = -1, riprap; = 0, smooth; = 1, other types
IUD	- integer used to convert design wind speed to an integer value, mph
IWIND	- factor for design wind; = 0, input overland design wind; = 1, wind values input from data provided in ETL 1110-2-221 (1 and 60 minute wind speeds)
IX	- total number of values of outputs to be printed for wind data and deepwater wave characteristics
J	- counter in determination of effective fetch; keeps track of which angle between a specific radial line and the central radial line to use in the computations
KFILE	- logical file designator for input data file and output file for graphics and/or other use; = 1, input file; = 2, output file
LQX	- equal 1, print instruction for RERUN; = 3, no print. No function in this subroutine (H7780), just uses COMMON to be passed to input subroutine H7780I
LQZ	- set equal to 1 if no permanent input data file exists; set equal to 2 if file exists. If = 1, execute cue "CHANGE ANY DATA BEFORE RUN, Y OR N"
NSTART	- set equal to 1 if permanent data file exists and this is first entry to file; set equal 0 if no permanent file or permanent file has already been entered. If = 1, execute cue "CHANGE ANY DATA BEFORE RUN, Y OR N"
NSAVE	- equal 1 or 2, save tabulated output for graphics and/or other use; = 0, no save
P	- wave exceedance in hundredths
PI	- constant = 3.14159265
PPEP(I)	- wave exceedance in percent for I = 1,...,20
R	- ratio of overwater wind speed to overland wind speed

RAD - constant = $\pi/180$; converts degrees to radians

RG - proportional distance of critical effective fetch between two fetch increments FI(I). Example, if critical effective fetch is 3.75 and FI(1) = 3 and FI(2) = 4, then RG = .75

RMAX - greatest radial length, miles

RP(I) - wave runup for waves other than the significant wave, for I = 1,...,20; ft

RS - significant wave runup, ft above SWL

RSS - total increase in water level, ft above SWL

S - wind setup, ft

SCOSAL - sum of the cosine of the angles between a specific radial line and the central radial line

SINB - sine; angle between embankment slope and horizontal

SITE(I) - 4 character variable, site ID name, for I = 1,...,15. Can have total of 60 characters for name

SXA - working storage; used in determination of effective fetch, miles

T(I) - significant wave period for deepwater wave characteristics, for I = 1,...,IX, sec

TD - design wave period, sec

TDC - wind duration as expressed by equations (B-2), (B-3), and (B-4), pages B-2 and B-3, Appendix B

TDF - value of equation (4) page 11

TDUR(I) - wind duration, wind data, and deepwater wave characteristics I = 1,...,IX; min

TDURD - design wind duration, min

TITLE(I) - 4 character variable, job title, for I = 1,...,15. Can have total of 60 characters for title

U - wind speed, mph

UD - design wind speed, mph

UF(I) - wind speed overwater for wind data and deepwater wave characteristics, I=1,...,IX; mph

UL - input overland wind speed, mph

US - wind speed, fps

U1 - maximum 1 minute wind speed, mph

U2 - input maximum 1 minute wind speed, mph

U30 - 30 minute wind speed, mph

U360 - 360 minute wind speed, mph

U60 - maximum 60 minute wind speed, mph

U61 - input maximum 60 minute wind speed, mph

WR(I) - wind factors corresponding to fetch increments FI(I), I = 1,...,7

I	WR	I	WR	I	WR
1	1	2	1.08	3	1.13
4	1.21	5	1.26	6	1.28
7	1.30				

X(I) - radial lengths, miles

XA - working storage in determination of effective fetch, miles

ZA - working storage used in determination of wave runup; equal to the expression $\left(\frac{H}{d_s}\right)^{1/2}$ (1.58 - 2.35 tan θ) of equation (11) page 14

ZB - working storage used in determination of wave runup; equal to the expression .092 cot θ - .26 of equation (11) page 14

ZC - working storage used in determination of wave runup; equal to the expression sin θ (5.95 tan θ + 1.5) of equation (10) page 14

ZE - value of equation (11) page 14

c. Subroutine H7780I: Variables are as explained in subroutine H7780, except

LQZ - equal 1, execute input cues and reads; = 2, call RERUN and enter only desired inputs

JKL - direct return from RERUN to desired input read

KKK - total number of inputs passed to RERUN

d. Subroutine H7780W: Variables are as explained in subroutine H7780 except

NLIN - number of lines in data file; maximum number of 13

LINE(I) - line number in data file; start at 100 and incremented by 2 for I = 2,...,NLIN

M8 - number of 8 variable lines required for writing radial length

MR - number of radial lengths left after M8 lines written

e. Subroutine H7780H: This subroutine writes the header information and tabulated output to the output file for graphics and/or other use. The header information may be seen in formats 20070 and 20100, line numbers 20070-20080 and 20100-20140 of the source listing, page 68. Variables are as explained in subroutine H7780 except

AFILE - 10 character variable used in attaching existing input data file

LINE(I) - line number in data file; start at 100 and increment by 2 for I = 1,...,IX; maximum number 50

10. <u>EXAMPLE CASE</u>: The example problems presented were taken from those given in ETL 1110-2-221 and ETL 1110-2-8 (references 1 and 10) for Dension and McGee Bend Reservoirs. Fetch, average depth, and slope inclination data used correspond to the values given in those references. Wind data used are based on the overland maximum one-minute and sixty-minute wind speeds obtained from the appropriate figures in reference 1. For demonstration purposes only, the depths at the toe of the structures and type of embankment slopes were arbitrarily selected. Examples 1 and 2 are for smooth embankment slopes and example 3 is a run with different data files using the RERUN option for turfed slopes, small stepped slopes, and riprapped slopes.

Example 1 Runs program with no permanent data file

```
RUN WESLIB/CORPS/H7780,R
```

```
INPUT  H7780 - WAVE RUNUP AND WIND SETUP,COMPUTATIONAL MODEL

PERM DATA FILE;Y OR N
=N
WE WILL HELP YOU SETUP YOUR DATAFILE. ENTER FILE NAME
=DH7780
AA-ENTER JOB TITLE < OR = 60 CHARACTERS
=DENSION RESERVOIR
AB-ENTER SITE ID < OR = 60 CHARACTERS
=STATION A
AC-ENTER THE NUMBER OF RADIALS USED TO DETERMINE EFFECTIVE
FETCH DISTANCE;A MINIMUM OF 15 RADIALS IS REQUIRED
=15
AD-ENTER THE 15 RADIAL LENGTHS IN MILES,SPEARATE BY COMMAS
=2.23,2.21,2.92,3.2,5.05,4.58,5.45,8.02,7.86,7.53,2.11,1.71,1.24
=1.25,1.22
AE-USE DESIGN OVERLAND WIND SPEED OR 1 MIN AND 60 MIN WIND SPEED
AS IN ETL 1110-2-221;0,DESIGN;1,1 MIN AND 60 MIN
=1
AF-ENTER 1 MIN AND 60 MIN WIND SPEEDS,MPH
=65,45
AG-ENTER FACTOR FOR DESIGN WAVE;0,DESIGN WAVE IS SIGNIFICANT
WAVE;1,DESIGN WAVE IS OTHER RELATED WAVE
=1
AH-ARE DEEP WATER WAVE CHARACTERISTICS TO BE PRINTED;0,NO PRINT;1,PRINT
=1
AI-ENTER WATER DEPTH AT TOE OF STRUCTURE,FT
=20
AJ-ENTER AVERAGE WATER DEPTH ALONG WIND FETCH,FT
=50
AK-ENTER COTANGENT OF ANGLE BETWEEN EMBANKMENT SLOPE AND HORIZONTAL
=2.5
AL-ENTER FACTOR FOR REDUCING WAVE RUNUP ON SMOOTH SLOPE WHERE SLOPE IS
SLIGHTLY ROUGHER THAN SMOOTH
=1
AM-ENTER SLOPE COVER ;-1,RIPRAP;0,SMOOTH;1,OTHER
=0
AN-SAVE TABULATED OUTPUT FOR GRAPHICS OR OTHER USE
=Y
FILE NAME
=PH7780
CHANGE ANY DATA BEFORE RUN,Y OR N
=N


OUTPUT  H7780 - WAVE RUNUP AND WIND SETUP,COMPUTATIONAL MODEL

DENSION RESERVOIR
STATION A

                                 BASIC DATA

    DEPTH AT TOE OF EMBANKMENT =    20.00 FT
    AVERAGE WATER DEPTH =    50.00 FT
    EMBANKMENT SLOPE =    2.50H:1V
    SMOoTH SLOPE MODIFICATION FACTOR =     1.00
    ONE MINUTE WIND SPEED =    65.00 MPH
    SIXTY MINUTE WIND SPEED =    45.00 MPH

       RADIALS CORRESPONDING TO CRITICAL EFFECTIVE FETCH IN MILES

       2.23    2.21    2.92    3.20    5.05    4.58    5.45    8.02
       7.86    7.53    2.11    1.71    1.24    1.25    1.22
```

COMPUTATIONAL RESULTS

EFFECTIVE WAVE FETCH = 3.75 MILES

TRANSITIONAL WATER WAVE CONDITIONS USED FOR PRESENT PROBLEM

EMBANKMENT SLOPE - SMOOTH

DESIGN WIND SPEED = 63.00 MPH
DESIGN WIND DURATION = 36.34 MIN
DESIGN WAVE HEIGHT = 5.29 FT
DESIGN WAVE PERIOD = 4.47 SEC
DESIGN DEEP WATER WAVE LENGTH = 102.80 FT
FETCH FOR WIND SETUP = 7.50 MILES
WIND SETUP = 0.42 FT
SIGNIFICANT WAVE RUNUP = 9.86 FT ABOVE SWL
TOTAL INCREASE IN WATER LEVEL = 10.29 FT ABOVE SWL

WIND DATA AND DEEP WATER WAVE CHARACTERISTICS

OVER WATER WIND SPEED (MPH)	WIND DURATION (MIN)	SIGNIFICANT WAVE HEIGHT (FT)	SIGNIFICANT WAVE PERIOD (SEC)
50.00	40.97	4.38	4.27
51.00	40.55	4.48	4.32
52.00	40.15	4.58	4.36
53.00	39.75	4.68	4.40
54.00	39.37	4.79	4.45
55.00	39.00	4.89	4.49
56.00	38.63	4.99	4.53
57.00	38.28	5.10	4.57
58.00	37.94	5.20	4.61
59.00	37.60	5.31	4.65
60.00	37.27	5.41	4.69
61.00	36.96	5.52	4.74
62.00	36.65	5.62	4.78
63.00	36.34	5.73	4.81
64.00	36.05	5.83	4.85
65.00	35.76	5.94	4.89
66.00	35.48	6.05	4.93
67.00	35.20	6.15	4.97
68.00	34.93	6.26	5.01
69.00	34.67	6.37	5.05
70.00	34.41	6.47	5.08
71.00	34.16	6.58	5.12
72.00	33.92	6.69	5.16
73.00	33.68	6.80	5.19
74.00	33.44	6.91	5.23
75.00	33.21	7.01	5.27
76.00	32.98	7.12	5.30
77.00	32.76	7.23	5.34
78.00	32.54	7.34	5.37
79.00	32.33	7.45	5.41
80.00	32.12	7.56	5.44
81.00	31.91	7.67	5.48

WAVE HEIGHTS AND WAVE RUNUP FOR WAVES OTHER THAN THE SIGINIFICANT WAVE
(NOTE- THE TERM WAVE EXCEEDENCE REFERS TO THE PERCENT OF WAVES IN
A WAVE SPECTRUM THAT EXCEEDS A GIVEN VALUE.)

WAVE EXCEEDANCE IN PERCENT	WAVE HEIGHT (FT)	WAVE RUNUP (FT)
1.00	8.03	14.97
2.00	7.40	13.80
3.00	7.01	13.06
4.00	6.71	12.51
5.00	6.48	12.07
6.00	6.28	11.70
7.00	6.10	11.38
8.00	5.95	11.09
9.00	5.81	10.82
10.00	5.68	10.58
11.00	5.56	10.36
12.00	5.45	10.16
13.00	5.34	9.96
14.00	5.25	9.78
15.00	5.15	9.61
16.00	5.06	9.44
17.00	4.98	9.29
18.00	4.90	9.13
19.00	4.82	8.99
20.00	4.75	8.85

ENTER RERUN OR STOP
=STOP

The user named input data file DH7780 is now saved as a permanent data on the user's ID. The following is a list of DH7780.

```
100 H7780
102 DENSION RESERVOIR
104 STATION A
106  15   0   1   1   1
108    20.00   50.00    2.50    1.00
110    65.00   45.00
112     2.23    2.21    2.92    3.20    5.05    4.58    5.45    8.02
114     7.86    7.53    2.11    1.71    1.24    1.25    1.22
```

The file PH7780, a user named output file for graphics and/or other use, is also saved on his/her ID. The following is a list of PH7780.

```
10 H7780 07 07 EDGE
11 (07(/),(3X,7(1X,F7.2)))
12  32  32  32  32  20  20  20
13  1  1  1  1  5  5  5
14 CURVE DESIGNATIONS FOR H7780 ARE:
15  1=OVER WATER WIND SPEED       2=WIND DURATION
16  3=SIGNIFICANT WAVE HEIGHT     4=SIGNIFICANT WAVE PERIOD
17  5=WAVE EXCEEDANCE             6=WAVE HEIGHT
18  7=WAVE RUNUP
19 UNITS FOR ABOVE VARIABLES ARE:
20  MPH=1  MIN=2  SEC=4  FT=3,6,7  PERCENT=5
100    50.00    40.97     4.38     4.27     1.00     8.03    14.97
102    51.00    40.55     4.48     4.32     2.00     7.40    13.80
104    52.00    40.15     4.58     4.36     3.00     7.01    13.06
106    53.00    39.75     4.68     4.40     4.00     6.71    12.51
108    54.00    39.37     4.79     4.45     5.00     6.48    12.07
110    55.00    39.00     4.89     4.49     6.00     6.28    11.70
112    56.00    38.63     4.99     4.53     7.00     6.10    11.38
114    57.00    38.28     5.10     4.57     8.00     5.95    11.09
116    58.00    37.94     5.20     4.61     9.00     5.81    10.82
118    59.00    37.60     5.31     4.65    10.00     5.68    10.58
120    60.00    37.27     5.41     4.69    11.00     5.56    10.36
122    61.00    36.96     5.52     4.74    12.00     5.45    10.16
124    62.00    36.65     5.62     4.78    13.00     5.34     9.96
126    63.00    36.34     5.73     4.81    14.00     5.25     9.78
128    64.00    36.05     5.83     4.85    15.00     5.15     9.61
130    65.00    35.76     5.94     4.89    16.00     5.06     9.44
132    66.00    35.48     6.05     4.93    17.00     4.93     9.29
134    67.00    35.20     6.15     4.97    18.00     4.90     9.13
136    68.00    34.93     6.26     5.01    19.00     4.82     8.99
138    69.00    34.67     6.37     5.05    20.00     4.75     8.85
140    70.00    34.41     6.47     5.08     0.       0.       0.
142    71.00    34.16     6.58     5.12     0.       0.       0.
144    72.00    33.92     6.69     5.16     0.       0.       0.
146    73.00    33.68     6.80     5.19     0.       0.       0.
148    74.00    33.44     6.91     5.23     0.       0.       0.
150    75.00    33.21     7.01     5.27     0.       0.       0.
152    76.00    32.98     7.12     5.30     0.       0.       0.
154    77.00    32.76     7.23     5.34     0.       0.       0.
156    78.00    32.54     7.34     5.37     0.       0.       0.
158    79.00    32.33     7.45     5.41     0.       0.       0.
160    80.00    32.12     7.56     5.44     0.       0.       0.
162    81.00    31.91     7.67     5.48     0.       0.       0.
```

Example 2 Run program using an existing permanent data file

```
INPUT  H7780 - WAVE RUNUP AND WIND SETUP,COMPUTATIONAL MODEL

PERM DATA FILE;Y OR N
=Y
DATAFILE NAME
=DH77801
CHANGE ANY DATA BEFORE RUN,Y OR N
=N


OUTPUT  H7780 - WAVE RUNUP AND WIND SETUP,COMPUTATIONAL MODEL

MCGEE BEND RESERVOIR
STATION A

                           BASIC DATA

    DEPTH AT TOE OF EMBANKMENT =   20.00 FT
    AVERAGE WATER DEPTH =   73.00 FT
    EMBANKMENT SLOPE =    2.50H:1V
    SMOOTH SLOPE MODIFICATION FACTOR =    1.00
    ONE MINUTE WIND SPEED =   55.00 MPH
    SIXTY MINUTE WIND SPEED =   50.00 MPH

       RADIALS CORRESPONDING TO CRITICAL EFFECTIVE FETCH IN MILES

       1.33   2.70   2.89   3.22   6.49  12.64  16.95  16.71
      12.31  11.74   6.39   5.87   5.59   3.46   3.41


                        COMPUTATIONAL RESULTS

    EFFECTIVE WAVE FETCH =    7.49 MILES


       TRANSITIONAL WATER WAVE CONDITIONS USED FOR PRESENT PROBLEM

 EMBANKMENT SLOPE - SMOOTH

    DESIGN WIND SPEED =   64.00 MPH
    DESIGN WIND DURATION =   61.01 MIN
    DESIGN WAVE HEIGHT =    7.18 FT
    DESIGN WAVE PERIOD =    5.31 SEC
    DESIGN DEEP WATER WAVE LENGTH =  144.43 FT
    FETCH FOR WIND SETUP =   14.98 MILES
    WIND SETUP =    0.60 FT
    SIGNIFICANT WAVE RUNUP =   14.18 FT ABOVE SWL
    TOTAL INCREASE IN WATER LEVEL =   14.78 FT ABOVE SWL
```

WIND DATA AND DEEP WATER WAVE CHARACTERISTICS

OVER WATER WIND SPEED (MPH)	WIND DURATION (MIN)	SIGNIFICANT WAVE HEIGHT (FT)	SIGNIFICANT WAVE PERIOD (SEC)
57.00	64.80	6.81	5.40
58.00	64.22	6.95	5.44
59.00	63.65	7.09	5.49
60.00	63.09	7.23	5.54
61.00	62.55	7.37	5.59
62.00	62.03	7.51	5.64
63.00	61.51	7.65	5.69
64.00	61.01	7.79	5.73
65.00	60.52	7.93	5.78
66.00	60.04	8.08	5.83
67.00	59.57	8.22	5.87
68.00	59.11	8.36	5.92
69.00	58.67	8.51	5.96
70.00	58.23	8.65	6.01

WAVE HEIGHTS AND WAVE RUNUP FOR WAVES OTHER THAN THE SIGINIFICANT WAVE
(NOTE- THE TERM WAVE EXCEEDENCE REFERS TO THE PERCENT OF WAVES IN
A WAVE SPECTRUM THAT EXCEEDS A GIVEN VALUE.)

WAVE EXCEEDANCE IN PERCENT	WAVE HEIGHT (FT)	WAVE RUNUP (FT)
1.00	10.90	21.52
2.00	10.05	19.84
3.00	9.51	18.78
4.00	9.11	17.99
5.00	8.79	17.36
6.00	8.52	16.82
7.00	8.28	16.35
8.00	8.07	15.94
9.00	7.88	15.56
10.00	7.71	15.22
11.00	7.55	14.90
12.00	7.40	14.60
13.00	7.25	14.32
14.00	7.12	14.06
15.00	7.00	13.81
16.00	6.88	13.58
17.00	6.76	13.35
18.00	6.65	13.13
19.00	6.54	12.92
20.00	6.44	12.72

ENTER RERUN OR STOP
=STOP

The following is a list of the permanent input data file DH77801 used in example 2.

```
100 H7780
102 MCGEE BEND RESERVOIR
104 STATION A
106   15   0   1   1   1
108    20.00   73.00    2.50    1.00
110    55.00   50.00
112     1.33    2.70    2.89    3.22    6.49   12.64   16.95   16.71
114    12.31   11.74    6.39    5.87    5.59    3.46    3.41
```

Example 3 Run program using different existing data files and the rerun option.

```
INPUT  H7780 - WAVE RUNUP AND WIND SETUP,COMPUTATIONAL MODEL

PERM DATA FILE;Y OR N
=Y
DATAFILE NAME
=DH7780
CHANGE ANY DATA BEFORE RUN,Y OR N
=Y
RERUN OPTION PERMITS YOU TO CHANGE ANY OR ALL INPUT VARIABLES.
AT >>>= QUE TYPE IN THE TWO LETTERS(AA,AB,ETC.) CORRESPONDING
TO THE VARIABLES YOU WISH TO CHANGE.  THEN AT NEXT = QUE, ENTER
THE NUMERICAL VALUE.  TO TERMINATE DATA ENTRY, TYPE A CARRIAGE
RETURN AT >>>= QUE.
>>>
=AG
AG-ENTER FACTOR FOR DESIGN WAVE;0,DESIGN WAVE IS SIGNIFICANT
WAVE;1,DESIGN WAVE IS OTHER RELATED WAVE
=0
>>>
=AH
AH-ARE DEEP WATER WAVE CHARACTERISTICS TO BE PRINTED;0,NO PRINT;1,PRINT
=0
>>>
=AL
AL-ENTER FACTOR FOR REDUCING WAVE RUNUP ON SMOOTH SLOPE WHERE SLOPE IS
SLIGHTLY ROUGHER THAN SMOOTH
=.9
>>>
=
```

```
OUTPUT  H7780 - WAVE RUNUP AND WIND SETUP,COMPUTATIONAL MODEL

DENSION RESERVOIR
STATION A

                          BASIC DATA

    DEPTH AT TOE OF EMBANKMENT =    20.00 FT
    AVERAGE WATER DEPTH =   50.00 FT
    EMBANKMENT SLOPE =    2.50H:1V
    SMOOTH SLOPE MODIFICATION FACTOR =     0.90
    ONE MINUTE WIND SPEED =   65.00 MPH
    SIXTY MINUTE WIND SPEED =   45.00 MPH

       RADIALS CORRESPONDING TO CRITICAL EFFECTIVE FETCH IN MILES

       2.23   2.21   2.92   3.20   5.05   4.58   5.45   8.02
       7.86   7.53   2.11   1.71   1.24   1.25   1.22

                     COMPUTATIONAL RESULTS

    EFFECTIVE WAVE FETCH =     3.75 MILES

       TRANSITIONAL WATER WAVE CONDITIONS USED FOR PRESENT PROBLEM

 EMBANKMENT SLOPE - MODIFIED SMOOTH

    DESIGN WIND SPEED =   63.00 MPH
    DESIGN WIND DURATION =   36.34 MIN
    DESIGN WAVE HEIGHT =    5.29 FT
    DESIGN WAVE PERIOD =    4.47 SEC
    DESIGN DEEP WATER WAVE LENGTH =  102.80 FT
    FETCH FOR WIND SETUP =     7.50 MILES
    WIND SETUP =    0.42 FT
    SIGNIFICANT WAVE RUNUP =    8.88 FT ABOVE SWL
    TOTAL INCREASE IN WATER LEVEL =    9.30 FT ABOVE SWL

ENTER RERUN OR STOP
=RERUN

INPUT  H7780 - WAVE RUNUP AND WIND SETUP,COMPUTATIONAL MODEL

CHANGE SPECIFIC ITEMS ON EXISTING DATA SET OR NEW DATA SET
NEW Y OR N
=Y
PERM DATA FILE;Y OR N
=Y
DATAFILE NAME
=DH77801
CHANGE ANY DATA BEFORE RUN,Y OR N
=Y
>>>
=AG
AG-ENTER FACTOR FOR DESIGN WAVE;0,DESIGN WAVE IS SIGNIFICANT
WAVE;1,DESIGN WAVE IS OTHER RELATED WAVE
=0
>>>
=AH
AH-ARE DEEP WATER WAVE CHARACTERISTICS TO BE PRINTED;0,NO PRINT;1,PRINT
=0
>>>
=AL
```

```
AL-ENTER FACTOR FOR REDUCING WAVE RUNUP ON SMOOTH SLOPE WHERE SLOPE IS
SLIGHTLY ROUGHER THAN SMOOTH
=.9
>>>
=


OUTPUT  H7780 - WAVE RUNUP AND WIND SETUP,COMPUTATIONAL MODEL

MCGEE BEND RESERVOIR
STATION A

                           BASIC DATA

    DEPTH AT TOE OF EMBANKMENT =   20.00 FT
    AVERAGE WATER DEPTH =   73.00 FT
    EMBANKMENT SLOPE =    2.50H:1V
    SMOOTH SLOPE MODIFICATION FACTOR =    0.90
    ONE MINUTE WIND SPEED =   55.00 MPH
    SIXTY MINUTE WIND SPEED =   50.00 MPH

       RADIALS CORRESPONDING TO CRITICAL EFFECTIVE FETCH IN MILES

       1.33   2.70   2.89   3.22   6.49  12.64  16.95  16.71
      12.31  11.74   6.39   5.87   5.59   3.46   3.41


                        COMPUTATIONAL RESULTS

    EFFECTIVE WAVE FETCH =    7.49 MILES


       TRANSITIONAL WATER WAVE CONDITIONS USED FOR PRESENT PROBLEM

 EMBANKMENT SLOPE - MODIFIED SMOOTH

    DESIGN WIND SPEED =   64.00 MPH
    DESIGN WIND DURATION =   61.01 MIN
    DESIGN WAVE HEIGHT =    7.18 FT
    DESIGN WAVE PERIOD =    5.31 SEC
    DESIGN DEEP WATER WAVE LENGTH =  144.43 FT
    FETCH FOR WIND SETUP =   14.98 MILES
    WIND SETUP =    0.60 FT
    SIGNIFICANT WAVE RUNUP =   12.76 FT ABOVE SWL
    TOTAL INCREASE IN WATER LEVEL =   13.36 FT ABOVE SWL

ENTER RERUN OR STOP
=RERUN

INPUT  H7780 - WAVE RUNUP AND WIND SETUP,COMPUTATIONAL MODEL

CHANGE SPECIFIC ITEMS ON EXISTING DATA SET OR NEW DATA SET
NEW Y OR N
=N
>>>
=AL
AL-ENTER FACTOR FOR REDUCING WAVE RUNUP ON SMOOTH SLOPE WHERE SLOPE IS
SLIGHTLY ROUGHER THAN SMOOTH
=.75
>>>
=
```

```
OUTPUT  H7780 - WAVE RUNUP AND WIND SETUP,COMPUTATIONAL MODEL

MCGEE BEND RESERVOIR
STATION A

                              BASIC DATA

    DEPTH AT TOE OF EMBANKMENT =    20.00 FT
    AVERAGE WATER DEPTH =   73.00 FT
    EMBANKMENT SLOPE =    2.50H:1V
    SMOOTH SLOPE MODIFICATION FACTOR =     0.75
    ONE MINUTE WIND SPEED =   55.00 MPH
    SIXTY MINUTE WIND SPEED =    50.00 MPH

       RADIALS CORRESPONDING TO CRITICAL EFFECTIVE FETCH IN MILES

       1.33    2.70    2.89    3.22    6.49   12.64   16.95   16.71
      12.31   11.74    6.39    5.87    5.59    3.46    3.41


                           COMPUTATIONAL RESULTS

    EFFECTIVE WAVE FETCH =     7.49 MILES


       TRANSITIONAL WATER WAVE CONDITIONS USED FOR PRESENT PROBLEM

 EMBANKMENT SLOPE - MODIFIED SMOOTH

    DESIGN WIND SPEED =   64.00 MPH
    DESIGN WIND DURATION =    61.01 MIN
    DESIGN WAVE HEIGHT =     7.18 FT
    DESIGN WAVE PERIOD =     5.31 SEC
    DESIGN DEEP WATER WAVE LENGTH =  144.43 FT
    FETCH FOR WIND SETUP =    14.98 MILES
    WIND SETUP =     0.60 FT
    SIGNIFICANT WAVE RUNUP =    10.64 FT ABOVE SWL
    TOTAL INCREASE IN WATER LEVEL =    11.24 FT ABOVE SWL

ENTER RERUN OR STOP
=RERUN

INPUT  H7780 - WAVE RUNUP AND WIND SETUP,COMPUTATIONAL MODEL

CHANGE SPECIFIC ITEMS ON EXISTING DATA SET OR NEW DATA SET
NEW Y OR N
=N
>>>
=AL
AL-ENTER FACTOR FOR REDUCING WAVE RUNUP ON SMOOTH SLOPE WHERE SLOPE IS
SLIGHTLY ROUGHER THAN SMOOTH
=1
>>>
=AM
AM-ENTER SLOPE COVER ;-1,RIPRAP;0,SMOOTH;1,OTHER
=-1
>>>
=
```

```
OUTPUT  H7780 - WAVE RUNUP AND WIND SETUP,COMPUTATIONAL MODEL

MCGEE BEND RESERVOIR
STATION A

                              BASIC DATA

    DEPTH AT TOE OF EMBANKMENT =   20.00 FT
    AVERAGE WATER DEPTH =   73.00 FT
    EMBANKMENT SLOPE =    2.50H:1V
    SMOOTH SLOPE MODIFICATION FACTOR =    1.00
    ONE MINUTE WIND SPEED =   55.00 MPH
    SIXTY MINUTE WIND SPEED =   50.00 MPH

       RADIALS CORRESPONDING TO CRITICAL EFFECTIVE FETCH IN MILES

       1.33    2.70    2.89    3.22    6.49   12.64   16.95   16.71
      12.31   11.74    6.39    5.87    5.59    3.46    3.41


                           COMPUTATIONAL RESULTS

    EFFECTIVE WAVE FETCH =     7.49 MILES


       TRANSITIONAL WATER WAVE CONDITIONS USED FOR PRESENT PROBLEM

 EMBANKMENT SLOPE - RIPRAP


    DESIGN WIND SPEED =   64.00 MPH
    DESIGN WIND DURATION =   61.01 MIN
    DESIGN WAVE HEIGHT =    7.18 FT
    DESIGN WAVE PERIOD =    5.31 SEC
    DESIGN DEEP WATER WAVE LENGTH =  144.43 FT
    FETCH FOR WIND SETUP =   14.98 MILES
    WIND SETUP =    0.60 FT
    SIGNIFICANT WAVE RUNUP =    7.50 FT ABOVE SWL
    TOTAL INCREASE IN WATER LEVEL =    8.10 FT ABOVE SWL

ENTER RERUN OR STOP
=RERUN

INPUT  H7780 - WAVE RUNUP AND WIND SETUP,COMPUTATIONAL MODEL

CHANGE SPECIFIC ITEMS ON EXISTING DATA SET OR NEW DATA SET
NEW Y OR N
=Y
PERM DATA FILE;Y OR N
=Y
DATAFILE NAME
=DH7780
CHANGE ANY DATA BEFORE RUN,Y OR N
=Y
>>>
=AL
AL-ENTER FACTOR FOR REDUCING WAVE RUNUP ON SMOOTH SLOPE WHERE SLOPE IS
SLIGHTLY ROUGHER THAN SMOOTH
=.75
>>>
=
```

```
OUTPUT  H7780 - WAVE RUNUP AND WIND SETUP,COMPUTATIONAL MODEL

DENSION RESERVOIR
STATION A

                          BASIC DATA

    DEPTH AT TOE OF EMBANKMENT =   20.00 FT
    AVERAGE WATER DEPTH =   50.00 FT
    EMBANKMENT SLOPE =    2.50H:1V
    SMOOTH SLOPE MODIFICATION FACTOR =    0.75
    ONE MINUTE WIND SPEED =   65.00 MPH
    SIXTY MINUTE WIND SPEED =   45.00 MPH

       RADIALS CORRESPONDING TO CRITICAL EFFECTIVE FETCH IN MILES

       2.23   2.21   2.92   3.20   5.05   4.58   5.45   8.02
       7.86   7.53   2.11   1.71   1.24   1.25   1.22

                       COMPUTATIONAL RESULTS

    EFFECTIVE WAVE FETCH =    3.75 MILES

       TRANSITIONAL WATER WAVE CONDITIONS USED FOR PRESENT PROBLEM

 EMBANKMENT SLOPE - MODIFIED SMOOTH

    DESIGN WIND SPEED =   63.00 MPH
    DESIGN WIND DURATION =   36.34 MIN
    DESIGN WAVE HEIGHT =    5.29 FT
    DESIGN WAVE PERIOD =    4.47 SEC
    DESIGN DEEP WATER WAVE LENGTH =  102.80 FT
    FETCH FOR WIND SETUP =    7.50 MILES
    WIND SETUP =    0.42 FT
    SIGNIFICANT WAVE RUNUP =    7.40 FT ABOVE SWL
    TOTAL INCREASE IN WATER LEVEL =    7.82 FT ABOVE SWL

ENTER RERUN OR STOP
=RERUN

INPUT  H7780 - WAVE RUNUP AND WIND SETUP,COMPUTATIONAL MODEL

CHANGE SPECIFIC ITEMS ON EXISTING DATA SET OR NEW DATA SET
NEW Y OR N
=N
>>>
=AL
AL-ENTER FACTOR FOR REDUCING WAVE RUNUP ON SMOOTH SLOPE WHERE SLOPE IS
SLIGHTLY ROUGHER THAN SMOOTH
=1
>>>
=AM
AM-ENTER SLOPE COVER ;-1,RIPRAP;0,SMOOTH;1,OTHER
=-1
>>>
=
```

```
OUTPUT  H7780 - WAVE RUNUP AND WIND SETUP,COMPUTATIONAL MODEL

DENSION RESERVOIR
STATION A

                         BASIC DATA

    DEPTH AT TOE OF EMBANKMENT =   20.00 FT
    AVERAGE WATER DEPTH =   50.00 FT
    EMBANKMENT SLOPE =    2.50H:1V
    SMOOTH SLOPE MODIFICATION FACTOR =    1.00
    ONE MINUTE WIND SPEED =   65.00 MPH
    SIXTY MINUTE WIND SPEED =   45.00 MPH

       RADIALS CORRESPONDING TO CRITICAL EFFECTIVE FETCH IN MILES

       2.23   2.21   2.92   3.20   5.05   4.58   5.45   8.02
       7.86   7.53   2.11   1.71   1.24   1.25   1.22


                      COMPUTATIONAL RESULTS

    EFFECTIVE WAVE FETCH =    3.75 MILES


       TRANSITIONAL WATER WAVE CONDITIONS USED FOR PRESENT PROBLEM

 EMBANKMENT SLOPE - RIPRAP


    DESIGN WIND SPEED =   63.00 MPH
    DESIGN WIND DURATION =   36.34 MIN
    DESIGN WAVE HEIGHT =    5.29 FT
    DESIGN WAVE PERIOD =    4.47 SEC
    DESIGN DEEP WATER WAVE LENGTH =  102.80 FT
    FETCH FOR WIND SETUP =    7.50 MILES
    WIND SETUP =    0.42 FT
    SIGNIFICANT WAVE RUNUP =    5.46 FT ABOVE SWL
    TOTAL INCREASE IN WATER LEVEL =    5.89 FT ABOVE SWL

ENTER RERUN OR STOP
=STOP
```

The following is a list of the permanent input data files DH7780 and DH77801 as changed by the last run of each file.

DH7780:

```
100 H7780
102 MCGEE BEND RESERVOIR
104 STATION A
106  15 -1  1  0  0
108   20.00  73.00   2.50   1.00
110   55.00  50.00
112    1.33   2.70   2.89   3.22   6.49  12.64  16.95  16.71
114   12.31  11.74   6.39   5.87   5.59   3.46   3.41
```

DH77801

```
100 H7780
102 [illegible] RESERVOIR
104 STATION A
106  15 -1   1   0   0
108    20.00  50.00   2.50   1.00
110    55.00  45.00
112     2.23   2.21   2.92   3.22   5.05   4.53   5.45   3.02
114     7.36   7.53   2.11   1.71   1.24   1.25   1.22
```

REF: ER 1110-1-10 - ENGINEERING AND DESIGN - Engineering and Computer Program Library Standards and Documentation, Appendix C

PART III: FILE DOCUMENTATION

1. REVISION LOG: Program coding revised June 78 to accommodate the CORPS time-share features.

2. TITLE: H7780 - Wave Runup and Wind Setup - Computational Model

3. PROGRAM SOURCE LISTINGS: See pages 59-68

4. NUMERICAL AND LOGICAL ANALYSIS: Wave runup and wind setup are solved by direct solution of algebraic equations except for the transitional depth wave length which is solved via an interactive technique.

5. SUBROUTINES NOT DOCUMENTED IN ABSTRACT: None

6. MISCELLANEOUS: The program is part of the CORPS computer system. CORPS is an acronym standing for Conversationally Oriented Real-Time Program-Generating System. The program is now operational on the WES G635, Vicksburg, MS; HIS 66/80, Macon, GA; and Boeing CDC, Seattle, WA. The source listing on page 59 contains the first line run command and brief for H7780. This first line run command runs the binary H7780B of the source listing on pages 60-68 (FORTRAN source of H7780) and attaches the WESLIB routines RERUN, HACCT, and TACHFILE.

```
0001*#RUN WESLIB/CORPS/H7780B,R;WESLIB/RERUN,R;WESLIB/HACCT,R;
0002*#WESLIB/TACHFILE,R
0800 62THE REQUIRED INPUTS FOR THIS PROGRAM CONSIST OF THE JOB TITLE,
0805 58THE SITE ID, THE NUMBER OF RADIALS(15 MINIMUM), THE RADIAL
0810 63LENGTHS IN MILES, WHETHER TO USE DESIGN OVERLAND WINDSPEED OR 1
0815 63MIN AND 60 MIN WIND SPEED, THE 1MIN AND 60MIN WIND SPEED OR THE
0820 63DESIGN OVERLAND WIND SPEED IN MPH, THE FACTOR FOR A SIGNIFICANT
0825 62DESIGN WAVE OR FOR OTHER RELATED DESIGN WAVE, WHETHER TO PRINT
0830 62THE DEEP WATER WAVE CHARACTERISTICS OR NOT, THE WATER DEPTH AT
0835 61THE TOE OF THE STRUCTURE IN FT, THE AVERAGE WATER DEPTH ALONG
0840 60WIND FETCH IN FT, THE COTANGENT OF THE ANGLE BETWEEN THE EM-
0845 63BANKMENT SLOPE AND THE HORIZONTAL, THE FACTOR FOR REDUCING WAVE
0850 62RUNUP ON SMOOTH SLOPE WHERE THE SLOPE IS SLIGHTLY ROUGHER THAN
0855 61SMOOTH, THE SLOPE COVER(RIPRAP, SMOOTH, OR OTHER),AND WHETHER
0860 55TO SAVE THE TABULATED OUTPUT FOR GRAPHICS OR OTHER USE.
0865 53OUTPUT INCLUDES THE BASIC DATA FROM THE INPUT AND THE
0870 62COMPUTATIONAL RESULTS WHICH INCLUDE THE EFFECTIVE WAVE FETCH
0875 60IN MILES, THE WATER WAVE CONDITIONS USED FOR PRESENT PROBLEM
0880 61(TYPE EMBANKMENT SLOPE, DESIGN WIND SPEED IN MPH, DESIGN WIND
0885 61DURATION IN MIN, DESIGN WAVE HEIGHT IN FT, DESIGN WAVE PERIOD
0890 59IN SEC, DESIGN DEEP WATER WAVE LENGTH IN FT, FETCH FOR WIND
0895 62SETUP IN MILES, WIND SETUP IN FT, SIGNIFICANT WAVE RUNUP IN FT
0900 62ABOVE SWL, AND TOTAL INCREASE IN WATER LEVEL IN FT ABOVE SWL),
0905 61AND, IF REQUESTED IN INPUT, THE WIND DATA AND DEEP WATER WAVE
0910 62CHARACTERISTICS(OVER WATER WIND SPEED IN MPH, WIND DURATION IN
0915 63MIN, SIGNIFICANT WAVE HEIGHT IN FT, AND SIGNIFICANT WAVE PERIOD
0920 60IN SEC) AND WAVE HEIGHTS AND WAVE RUNUP FOR WAVES OTHER THAN
0925 63THE SIGNIFICANT WAVE(WAVE EXCEEDANCE IN PERCENT, WAVE HEIGHT IN
0930 22FT, WAVE RUNUP IN FT).
0999*06FINISH
```

```
00001*#RUN *=;WESLIB/CORPS/H7780B(NOGO)
09000 CHARACTER HFILE*5
09010 COMMON /MAIN/LQZ,LQX/C77805/HFILE
09020 HFILE=5HH7780
09030 LQZ=1;LQX=1
09040 15000 PRINT 10006
09050 10006 FORMAT(/"INPUT  H7780 - WAVE RUNUP AND WIND SETUP,COMPUTATIO
09060&NAL MODEL"//)
09070 CALL HACCT(HFILE)
09090 IF(LQZ.NE.1) GO TO 15005
09100 CALL H7780($15011)
09110 GO TO 15010
09120 15005 PRINT 9125
09125 9125 FORMAT("CHANGE SPECIFIC ITEMS ON EXISTING DATA SET OR NEW DA
09127&TA SET"/"NEW Y OR N")
09130 CALL ANSWER($15006,$15007)
09140 15006 CALL DETACH(1,,);CALL H77803($15011);GO TO 15010
09150 15007 CALL H7780I($15011)
09160 CALL H77802($15011)
09170 15010 LQZ=2
09180 15011 PRINT," "
09190 CHARACTER ZZZZZZ*2
09200 16000 PRINT, "ENTER RERUN OR STOP"
09210 READ 16001, ZZZZZZ
09220 16001  FORMAT(A2)
09230 IF(ZZZZZZ.EQ.2HRE) GO TO 15000
09240 IF(ZZZZZZ.EQ.2HST) GO TO 20000
09250 PRINT,"ERROR *** RETYPE"
09260 GO TO 16000
09270 20000  STOP;END
09999 SUBROUTINE H7780(*)
10000 COMMON /MAIN/LQZ,LQX/C77801/KFILE,FILEK(2)/C77802/NSTART,NSAVE,TIT
10010&LE(15),SITE(15),IMM,ITYPE,IWIND,IDES,ITAB,D1,D,COTTH,FACT,U2,U61,U
10020&L/C77803/X(50)/C77804/UF(50),T(50),H(50),TDUR(50),RP(20),HP(20),PP
10030&EP(20),IX/C77805/HFILE
10040 DIMENSION ALPHA(8),FI(7),WR(7),GD(5)
10050 CHARACTER FILEK*8,TITLE*4,SITE*4,FILET*8,HFILE*5
10060 DATA FI,WR,GD,GRAV,SCOSAL,PI/0.,.5,1.,2.,3.,4.,5.,1.,1.08,1.13,1.2
10070&1,1.26,1.28,1.3,6.5882,.0161,.3692,2.2024,.8798,32.2,13.51091739,3
10075&.14159265/
10078 C=22./15.;RAD=PI/180.
10080 DO 10090 I=1,8
10090 10090 ALPHA(I)=(48-I*6)*RAD
10100 ENTRY H77803(*)
10110 NSTART=0;LQZ=1;KFILE=1
10120 PRINT,"PERM DATA FILE;Y OR N"
10130 CALL ANSWER($10200,$10140)
10140 10140 PRINT,"WE WILL HELP YOU SETUP YOUR DATAFILE. ENTER FILE NAME
10150&"
10160 READ,FILEK(KFILE)
```

```
10170 CALL H7780I($10190);DS=D1;U1=U2;U60=U61
10180 GO TO 10370
10190 10190 RETURN 1
10200 10200 PRINT,"DATAFILE NAME"
10210 READ,FILEK(KFILE);NSTART=1;LQZ=2
10220 ENTRY H77802(*);DS=D1;U1=U2;U60=U61
10230 10230 CALL TACHFILE(HFILE,$10190)
10240 REWIND KFILE
10250 READ(KFILE,10260) FILET
10260 10260 FORMAT(4X,A8)
10330 10330 READ(KFILE,10350,END=10370) TITLE,SITE,IMM,ITYPE,IWIND,IDES,
10340&ITAB,D1,D,COTTH,FACT,U2,U61,(X(J),J=1,IMM);DS=D1;U1=U2;U60=U61
10350 10350 FORMAT(4X,15A4/4X,15A4/4X,5I3/4X,4F7.2/4X,2F7.2,7(/4X,8F7.2)
10360&)
10370 10370 IF(NSTART.EQ.0.AND.LQZ.EQ.2) GO TO 10420
10375 PRINT 10380
10380 10380 FORMAT("CHANGE ANY DATA BEFORE RUN,Y OR N")
10390 CALL ANSWER($10400,$10420)
10400 10400 LQZ=2;CALL H77801($10190)
10410 GO TO 10230
10420 10420 IF(IWIND.EQ.1) GO TO 10440
10430 UL=U1;U60=0.
10440 10440 PRINT 10450,TITLE,SITE
10450 10450 FORMAT(///"OUTPUT  H7780 - WAVE RUNUP AND WIND SETUP,COMPUTA
10455&TIONAL MODEL"//15A4/15A4//28X,"BASIC DATA"//)
10460 PRINT 10470,D1,D,COTTH,FACT
10470 10470 FORMAT(5X,29HDEPTH AT TOE OF EMBANKMENT = ,F7.2,3H FT/5X,22H
10480&AVERAGE WATER DEPTH = ,F7.2,3H FT/5X,19HEMBANKMENT SLOPE = ,F7.2,4
10490&HH:1V/5X,35HSMOOTH SLOPE MODIFICATION FACTOR = ,F7.2)
10500 IF(IWIND.EQ.1) GO TO 10540
10510 PRINT 10520,UL
10520 10520 FORMAT(5X,31HOBSERVED OVERLAND WIND SPEED = ,F7.2,4H MPH)
10530 GO TO 10570
10540 10540 PRINT 10550,U2,U61
10550 10550 FORMAT(5X,24HONE MINUTE WIND SPEED = ,F7.2,4H MPH/5X,26HSIXT
10560&Y MINUTE WIND SPEED = ,F7.2,4H MPH)
10570 10570 FE=0.;II=1;IJK=15
10580 10580 J=0;IFIN=0;SXA=0.
10590 DO 10660 I=II,IJK
10600 IF(IFIN.EQ.1) GO TO 10640
10610 J=J+1
10620 IF(J.EQ.8) IFIN=1
10630 GO TO 10650
10640 10640 J=J-1
10650 10650 XA=X(I)*COS(ALPHA(J))**2
10660 10660 SXA=SXA+XA
10670 F=SXA/SCOSAL
10680 IF(FE.GT.F) GO TO 10700
10690 IK=II;FE=F
10700 10700 IF(IJK.EQ.IMM) GO TO 10720
```

```
II=II+1;IJK=IJK+1;GO TO 10580
10720 PRINT 10730
10730 FORMAT(//8X,58HRADIALS CORRESPONDING TO CRITICAL EFFECTIVE
& FETCH IN MILES//)
IL=IK+14
PRINT 10770,(X(I),I=IK,IL)
10770 FORMAT(5X,8F7.2)
PRINT 10790,FE
10790 FORMAT(///25X,"COMPUTATIONAL RESULTS"//5X,23HEFFECTIVE WAVE
&FETCH = ,F7.2,6H MILES)
FES=FE*5280.;RMAX=0.
DO 10840 I=IK,IL
IF(RMAX.LT.X(I)) RMAX=X(I)
10840 CONTINUE
IF(FE.GE.5.) GO TO 10930
INC=0
10870 INC=INC+1
IF(FI(INC).GE.FE) GO TO 10900
GO TO 10870
10900 RG=(FE-FI(INC-1))/(FI(INC)-FI(INC-1))
R=RG*(WR(INC)-WR(INC-1))+WR(INC-1)
GO TO 10940
10930 R=1.3
10940 IF(IWIND.EQ.0) GO TO 11260
U1=R*U1
U120=.96*R*U60
U360=.88*R*U60
U60=U60*R
IX=U1-U360
U=AINT(U360)
A60=ALOG(60.);A360=ALOG(360.);AU60=ALOG(U60);AU360=ALOG(U360)
US=U1*C
11030 GFU=GRAV*FES/US**2;GF1=ALOG(GFU)
ALN=GD(2)*GF1**2
BLN=GD(3)*GF1-GD(4)
DLN=GD(5)*GF1
TDF=(US*GD(1)*EXP(SQRT(ALN-BLN)+DLN))/(GRAV*60.)
IF(TDF.LE.60.) GO TO 11140
A1=(AU60-AU360)/(A60-A360)
A0=EXP(AU60-A1*A60)
A1=ABS(1./A1)
TDC=(C*A0/US)**A1
GO TO 11190
11140 U30=.3*U1+.7*U60
IF(TDF.LE.30.) GO TO 11180
TDC=(U30-US/C)*30./(U30-U60)+30.
GO TO 11190
11180 TDC=(U1-US/C)*29./(U1-U30)+1.
11190 IF(TDF.GT.TDC) GO TO 11210
US=US+.1;GO TO 11220
```

```
11210 US=US-1.
11220 IF(TDF-TDC.LT..2) GO TO 11240
GO TO 11030
11240 IUD=US/C
UD=IUD;GO TO 11290
11260 IX=20
UD=R*UL;IUD=UD;UD=IUD
U=UD-10.
11290 AU=0.
DO 11450 I=1,IX
UF(I)=U+AU
US=UF(I)*C
GFU=GRAV*FES/US**2;GF1=ALOG(GFU)
GT=TANH(.077*GFU**.25)
GH=TANH(.0125*GFU**.42)
T(I)=2.4*PI*GT*US/GRAV
H(I)=.283*US**2*GH/GRAV
ALN=GD(2)*GF1**2
BLN=GD(3)*GF1-GD(4)
DLN=GD(5)*GF1
TDUR(I)=(US*GD(1)*EXP(SQRT(ALN-BLN)+DLN))/(GRAV*60.)
IF(UF(I)-UD) 11440,11430,11440
11430 TD=T(I);HD=H(I);UD=UF(I);TDURD=TDUR(I)
11440 AU=AU+1.
11450 CONTINUE
11460 DL=GRAV*TD**2/(2.*PI)
C0=DL/TD
IF(D/DL.LE..5) GO TO 11530
PRINT 11500
11500 FORMAT(///8X,51HDEEP WATER WAVE CONDITIONS USED FOR PRESENT
&PROBLEM)
GO TO 11850
11530 IF(D/DL.LT..04) GO TO 11580
PRINT 11550
11550 FORMAT(///8X,59HTRANSITIONAL WATER WAVE CONDITIONS USED FOR
&PRESENT PROBLEM)
GO TO 11610
11580 PRINT 11590
11590 FORMAT(///11X,54HSHALLOW WATER WAVE CONDITIONS USED FOR PRES
&ENT PROBLEM)
11610 US=UD*C
GFU=GRAV*FES/US **2
GDU=GRAV*D/US**2
G2=TANH(.833*GDU**.375)
G1=TANH(.53*GDU**.75)
G3=.283*G1*TANH(.0125*GFU**.42/G1)
HD=US**2*G3/GRAV
G4=1.2*G2*TANH(.077*GFU**.25/G2)
TD=2.*PI*US*G4/GRAV
IF(D/DL.LT..04) GO TO 11820
```

```
11710 ALEN=DL
11720 GTA=GRAV*TD**2/(2.*PI)
11730 GTB=2.*PI*D
11740 11740 BLEN=GTA*TANH(GTB/ALEN)
11750 DIFF=ALEN-BLEN
11760 ADIFF=ABS(DIFF)
11770 IF(ADIFF.LE.1.) GO TO 11810
11780 IF(DIFF) 11800,11800,11790
11790 11790 ALEN=ALEN-1.;GO TO 11740
11800 11800 ALEN=ALEN+1.;GO TO 11740
11810 11810 DL=ALEN;GO TO 11850
11820 11820 TD=2.*PI*US*G4/GRAV
11840 DL=TD*SQRT(GRAV*D)
11850 11850 FS=2.*FE
11860 IF(FS.LE.RMAX) GO TO 11880
11870 FS=RMAX
11880 11880 S=FS*UD**2/(1400.*D)
11890 DS=DS+S
11900 IF(ITYPE) 11910,12050,12310
11910 11910 IF(COTTH.LT.5.) GO TO 11960
11920 PRINT 11930
11930 11930 FORMAT(/1X,57HPROGRAM CANNOT COMPUTE RUNUP ON SLOPES FLATTER
11940&THAN 1 ON 5)
11950 GO TO 12310
11960 11960 IF(COTTH.GT.2.) GO TO 12010
11970 PRINT 11980
11980 11980 FORMAT(/70HPROGRAM CANNOT COMPUTE RUNUP ON A VERTICAL OR NEA
11990&R VERTICAL EMBANKMENT)
12000 GO TO 12310
12010 12010 RS=HD/(.4+SQRT(HD/(GRAV*TD**2/(2.*PI))))*COTTH)
12020 PRINT 12030
12030 12030 FORMAT(/2X,25HEMBANKMENT SLOPE - RIPRAP//)
12040 GO TO 12300
12050 12050 IF(COTTH-1.5) 12060,12210,12060
12060 12060 IF(COTTH.GE.2.25) GO TO 12110
12070 PRINT 12080
12080 12080 FORMAT(/1X,49HPROGRAM CANNOT COMPUTE WAVE RUNUP FOR SLOPE GI
12090&VEN)
12100 GO TO 12310
12110 12110 IF(COTTH.GT.6.) GO TO 12190
12120 ZA=(1.58-2.35/COTTH)*SQRT(HD/DS)
12130 ZB=.092*COTTH-.26
12140 ZE=ZA+ZB
12150 SINB=1./SQRT(COTTH**2+1.)
12160 ZC=SINB*(5.95/COTTH+1.5)
12170 RS=HD*ZC*(.123*DL/HD)**ZE
12180 GO TO 12230
12190 12190 RS=.4*TD*SQRT(GRAV*HD)/COTTH
12200 GO TO 12230
12210 12210 ZE=.56*SQRT(HD/DS)-.18
```

```
RS=HD*2.3*(.123*DL/HD)**ZE
12230 RS=FACT*RS
IF(FACT-1.) 12280,12250,12280
12250 PRINT 12260
12260 FORMAT(/2X,25HEMBANKMENT SLOPE - SMOOTH)
GO TO 12300
12280 PRINT 12290
12290 FORMAT(/2X,34HEMBANKMENT SLOPE - MODIFIED SMOOTH)
12300 RSS=S+RS;GO TO 12340
12310 PRINT 12320
12320 FORMAT(/5X,51HRUNUP IS TO BE DETERMINED FROM FIG.13,ETL 1110
&-2-21)
12340 PRINT 12350,UD,TDURD,HD,TD,DL,FS,S
12350 FORMAT(/5X,20HDESIGN WIND SPEED = ,F7.2,4H MPH/5X,23HDESIGN
& WIND DURATION = ,F7.2,4H MIN/5X,21HDESIGN WAVE HEIGHT = ,F7.2,3H
& FT/5X,21HDESIGN WAVE PERIOD = ,F7.2,4H SEC/5X,32HDESIGN DEEP WATE
&R WAVE LENGTH = ,F7.2,3H FT/5X,23HFETCH FOR WIND SETUP = ,F7.2,6H
&MILES/5X,13HWIND SETUP = ,F7.2,3H FT)
IF(ITYPE.GT.0) GO TO 12440
PRINT 12420,RS,RSS
12420 FORMAT(5X,25HSIGNIFICANT WAVE RUNUP = ,F7.2,13H FT ABOVE SWL
&/5X,32HTOTAL INCREASE IN WATER LEVEL = ,F7.2,13H FT ABOVE SWL)
12440 IF(ITAB.EQ.0) GO TO 12610
PRINT 12550
12550 FORMAT(///14X,45HWIND DATA AND DEEP WATER WAVE CHARACTERISTI
&CS//6X,10HOVER WATER,8X,4HWIND,2X,2(6X,11HSIGNIFICANT)/6X,10HWIND
&SPEED,6X,8HDURATION,6X,11HWAVE HEIGHT,6X,11HWAVE PERIOD/8X,5H(MPH
&),11X,5H(MIN),10X,4H(FT),13X,5H(SEC)//)
PRINT 12600,(UF(I),TDUR(I),H(I),T(I),I=1,IX)
12600 FORMAT((6X,F7.2,9X,F7.2,8X,F7.2,10X,F7.2))
12610 IF(IDES.EQ.0.OR.ITYPE.GT.0) GO TO 12740
PRINT 12630
12630 FORMAT(///1X,70HWAVE HEIGHTS AND WAVE RUNUP FOR WAVES OTHER
& THAN THE SIGINIFICANT WAVE/3X,65H(NOTE- THE TERM WAVE EXCEEDENCE
& REFERS TO THE PERCENT OF WAVES IN/5X,44HA WAVE SPECTRUM THAT EXCE
&EDS A GIVEN VALUE.)//1X,2(12X,4HWAVE),8X,4HWAVE/10X,10HEXCEEDANCE,
&8X,6HHEIGHT,6X,6H RUNUP/10X,10HIN PERCENT,9X,4H(FT),8X,4H(FT)//)
DO 12710 I=1,20
AI=I;P=AI/100.;PPEP(I)=AI
RP(I)=RS*SQRT(ALOG(1./P)/2.)
12710 HP(I)=HD*RP(I)/RS
PRINT 12730,(PPEP(I),HP(I),RP(I),I=1,20)
12730 FORMAT((10X,F7.2,9X,F7.2,5X,F7.2))
12740 IF(NSAVE.NE.1.AND.NSAVE.NE.2) GO TO 12770
KFILE=2; CALL H7780H(NSAVE)
KFILE=1
12770 RETURN
END
SUBROUTINE H7780I(*)
COMMON /MAIN/LQZ,LQX/C77801/KFILE,FILEK(2)/C77802/NSTART,NSAVE,TIT
```

```
&LE(15),SITE(15),IMM,ITYPE,IWIND,IDES,ITAB,D1,D,COTTH,FACT,U2,U61,U
&L/C77803/X(50)/C77805/HFILE
CHARACTER FILEK*8,TITLE*4,SITE*4,HFILE*5
IF(LQZ.EQ.3) GO TO 14090
ENTRY H77801(*)
IF(LQZ.EQ.2.OR.NSTART.EQ.0) GO TO 14090
LQZ=2;REWIND KFILE
14090 KKK=14
IF(LQZ.EQ.1) GO TO 14140
14110 CALL RERUN(KKK,LQX,JKL)
GO TO(14140,14180,14210,14240,14270,14310,14390,14440,14480,14510,
&14540,14580,14630,14660,14730),JKL
14140 PRINT,"AA-ENTER JOB TITLE < OR = 60 CHARACTERS"
READ 14160,TITLE
14160 FORMAT(15A4)
GO TO (14180,14110),LQZ
14180 PRINT,"AB-ENTER SITE ID < OR = 60 CHARACTERS"
READ 14160,SITE
GO TO(14210,14110),LQZ
14210 PRINT 14215
14215 FORMAT("AC-ENTER THE NUMBER OF RADIALS USED TO DETERMINE EFF
&ECTIVE"/"FETCH DISTANCE;A MINIMUM OF 15 RADIALS IS REQUIRED")
READ,IMM
GO TO(14240,14110),LQZ
14240 PRINT 14245,IMM
14245 FORMAT("AD-ENTER THE ",I2," RADIAL LENGTHS IN MILES,SPEARATE
& BY COMMAS")
READ,(X(I),I=1,IMM)
GO TO(14270,14110),LQZ
14270 PRINT 14280
14280 FORMAT("AE-USE DESIGN OVERLAND WIND SPEED OR 1 MIN AND 60 MI
&N WIND SPEED"/"AS IN ETL 1110-2-221;0,DESIGN;1,1 MIN AND 60 MIN")
READ,IWIND
14310 IF(IWIND.NE.1) GO TO 14350
PRINT,"AF-ENTER 1 MIN AND 60 MIN WIND SPEEDS,MPH"
READ,U2,U61
GO TO 14380
14350 PRINT,"AF-ENTER DESIGN OVERLAND WIND SPEED,MPH"
READ,UL
U2=UL;U61=0.
14380 GO TO(14390,14110),LQZ
14390 PRINT 14400
14400 FORMAT("AG-ENTER FACTOR FOR DESIGN WAVE;0,DESIGN WAVE IS SIG
&NIFICANT"/"WAVE;1,DESIGN WAVE IS OTHER RELATED WAVE")
READ,IDES
GO TO(14440,14110),LQZ
14440 PRINT,"AH-ARE DEEP WATER WAVE CHARACTERISTICS TO BE PRINTED;
&0,NO PRINT;1,PRINT"
READ,ITAB
GO TO(14480,14110),LQZ
```

```
14480 PRINT,"AI-ENTER WATER DEPTH AT TOE OF STRUCTURE,FT"
READ,D1
GO TO(14510,14110),LQZ
14510 PRINT,"AJ-ENTER AVERAGE WATER DEPTH ALONG WIND FETCH,FT"
READ,D
GO TO(14540,14110),LQZ
14540 PRINT,"AK-ENTER COTANGENT OF ANGLE BETWEEN EMBANKMENT SLOPE
&AND HORIZONTAL"
READ,COTTH
GO TO(14580,14110),LQZ
14580 PRINT14590
14590 FORMAT("AL-ENTER FACTOR FOR REDUCING WAVE RUNUP ON SMOOTH SL
&OPE WHERE SLOPE IS"/"SLIGHTLY ROUGHER THAN SMOOTH")
READ,FACT
GO TO(14630,14110),LQZ
14630 PRINT,"AM-ENTER SLOPE COVER ;-1,RIPRAP;0,SMOOTH;1,OTHER"
READ,ITYPE
GO TO(14660,14110),LQZ
14660 PRINT,"AN-SAVE TABULATED OUTPUT FOR GRAPHICS OR OTHER USE"
CALL ANSWER($14680,$14770)
14680 NSAVE=1;KFILE=2
PRINT,"FILE NAME"
READ,FILEK(KFILE)
CALL TACHFILE(HFILE,$14760)
14720 GO TO (14730,14110),LQZ
14730 KFILE=1
CALL H7780W($14760,$14750)
14750 NSTART=0;RETURN
14760 RETURN 1
14770 NSAVE=0;GO TO 14720
END
SUBROUTINE H7780W(*,*)
COMMON /MAIN/LQZ,LQX/C77801/KFILE,FILEK(2)/C77802/NSTART,NSAVE,TIT
&LE(15),SITE(15),IMM,ITYPE,IWIND,IDES,ITAB,D1,D,COTTH,FACT,U2,U61,U
&L/C77803/X(50)/C77805/HFILE
DIMENSION LINE(13)
CHARACTER FILEK*8,TITLE*4,SILE*4,HFILE*5
CALL TACHFILE(HFILE,$16240)
REWIND KFILE
LINE(1)=100
M8=IMM/8;NLIN=M8+6
MR=IMM-M8*8
IF(MR.EQ.0) GO TO 16130
M8=M8+1;NLIN=NLIN+1
16130 DO 16140 I=2,NLIN
16140 LINE(I)=LINE(I-1)+2
WRITE(KFILE,16180) LINE(1),LINE(2),TITLE,LINE(3),SITE,LINE(4),IMM,
&ITYPE,IWIND,IDES,ITAB,LINE(5),D1,D,COTTH,FACT,LINE(6),U2,U61,(LINE
&(I+6),(X(J),J=(I-1)*8+1,I*8-(8-MR)*(I/M8)),I=1,M8)
16180 FORMAT(I3," H7780",2(/I3,1X,15A4)/I3,1X,5I3/I3,1X,4F7.2/I3,1
```

```
&X,2F7.2,7(/I3,1X,8F7.2))
CALL DETACH(KFILE,,)
IF(NSTART.EQ.1) GO TO 16250
NSTART=0
RETURN 2
16240 RETURN 1
16250 NSTART=0; RETURN
END
SUBROUTINE H7780H(NSAVE)
COMMON /C77801/KFILE,FILEK(2)/C77804/UF(50),T(50),H(50),TDUR(50),R
&P(20),HP(20),PPEP(20),IX
CHARACTER FILEK*8,AFILE*10,FORM*7
DIMENSION LINE(50)
IF(NSAVE.NE.1) GO TO 20260
WRITE(KFILE,20070) (IX,I=1,4)
20070 FORMAT("10 H7780 07 07 EDGE"/"11 (07(/),(3X,7(1X,F7.2)))"/"1
&2",4(1X,I3),3(2X,"20")/"13",4(2X,"1"),3(2X,"5"))
WRITE(KFILE,20100)
20100 FORMAT("14 CURVE DESIGNATIONS FOR H7780 ARE:"/"15  1=OVER WA
&TER WIND SPEED",5X,"2=WIND DURATION"/"16  3=SIGNIFICANT WAVE HEIGH
&T   4=SIGNIFICANT WAVE PERIOD"/"17  5=WAVE EXCEEDANCE",11X,"6=WAVE
& HEIGHT"/"18  7=WAVE RUNUP"/"19 UNITS FOR ABOVE VARIABLES ARE:"/"2
&0  MPH=1  MIN=2  SEC=4  FT=3,6,7  PERCENT=5")
20150 LINE(1)=100
DO 20170 I=2,IX
20170 LINE(I)=LINE(I-1)+2
IF(IX.GE.20) GO TO 20180
DO 20176 I=IX+1,20
20176 LINE(I)=LINE(I-1)+2
20180 WRITE(KFILE,20200) (LINE(I),UF(I),TDUR(I),H(I),T(I),PPEP(I),
&HP(I),RP(I),I=1,20)
20200 FORMAT((I3,7(1X,F7.2)))
IF(IX.LE.20) GO TO 20240
WRITE(KFILE,20230) (LINE(I),UF(I),TDUR(I),H(I),T(I),I=21,IX)
20230 FORMAT((I3,4(1X,F7.2),4X,"0.",2(6X,"0.")))
20240 CALL DETACH(KFILE,,);NSAVE=2
RETURN
20260 ENCODE(AFILE,20270) FILEK(KFILE)
20270 FORMAT("/",A8,";")
CALL ATTACH(KFILE,AFILE,3,0,,);LH=11
ENCODE(FORM,20300) LH
20300 FORMAT("(",I2,"(/))")
READ(KFILE,FORM)
GO TO 20150
END
```

APPENDIX A

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APPENDIX B

Design Wind Speed and Wind Duration Determinations

The method used in the present computer program for determining the design wind speed, based on regional wind data, is for all practical purposes consistent with the approach presented in ETL 1110-2-221. The method presented in the ETL requires plotting two wind velocity-duration curves, one based on regional wind and duration data, and one based on data from wave forecasting curves for a given wave fetch. Example wind velocity-duration curves are shown in Figure D-1 of the ETL. The intersection of the two curves are taken to yield the design wind speed and corresponding wind duration. In the present scheme, equations are written to describe the wind velocity-duration curve based on regional wind data. The empirical formula used for constructing wind velocity-duration curves in connection with the wave forecasting curves is equated to the equations describing the wind velocity-duration based on regional data. By an iterative process this technique yields the design wind and corresponding wind duration. The procedures and formulae used for determining these design values are covered in the following paragraphs.

Three equations are used to reproduce the wind velocity-duration curve for the regional wind data. One equation provides solutions for wind speeds with durations from 1 to 30 minutes, one for wind speeds with durations from 30 minutes to 60 minutes, and one for wind speeds with durations from 60 to 360 minutes. As discussed in paragraph 5-C-1, basic wind input consists of wind speeds corresponding to wind durations of 1 and 60 minutes. The wind speeds for these durations are defined symbolically as U and U_{60}, respectively. Equations of straight lines are used to obtain solutions of wind duration as a function of wind speed for wind durations ranging from 1 to 30 minutes and from 30 to 60 minutes. The 30-minute wind speed, U_{30}, is estimated by

$$U_{30} = \left(\frac{U_1 + U_{60}}{2}\right) - K \frac{(U_1 - U_{60})}{2} \qquad \text{(B-1)}$$

The factor K is taken to be 0.40 based on the curve shown in Figure D-1 in the ETL. Thus this number is simply a reduction factor for estimating the 30-minute wind speed. The wind duration t_{dc}, for the interval between 1 and 30 minutes as a function of the wind speed is given by

$$t_{dc} = 1 + \frac{29\ (U_1 - U)}{U_1 - U_{30}}\ ;\ 1 \le t_{dc} \le 30 \qquad \text{(B-2)}$$

and for the interval between 30 and 60 minutes by

$$t_{dc} = 30 + \frac{30\ (U_{30} - U)}{U_{30} - U_{60}}\ ;\ 30 \le t_{dc} \le 60 \qquad \text{(B-3)}$$

where U is the actual wind speed in the specific wind duration interval.

In the wind duration interval between 60 and 360 minutes a logarithmic transformation is used to describe wind duration as a function of the wind. This relation is given by

$$T_{dc} = \left[\frac{\exp(\ln U_{60} - A \ln 60)}{U}\right]^{1/A} \quad ; 60 \leq t_{dc} \leq 360 \qquad \text{(B-4)}$$

where A is

$$A = \frac{\ln U_{60} - \ln U_{360}}{\ln 60 - \ln 360} \qquad \text{(B-5)}$$

The symbol $\exp(x) = e^x$ and ln represents the natural logarithm.

The design wind and corresponding wind duration can be found equating either equation B-2, B-3, or B-4 to equation (4) by varying the wind speed U in an appropriate range. This is done by an iterative process in the computer routine.